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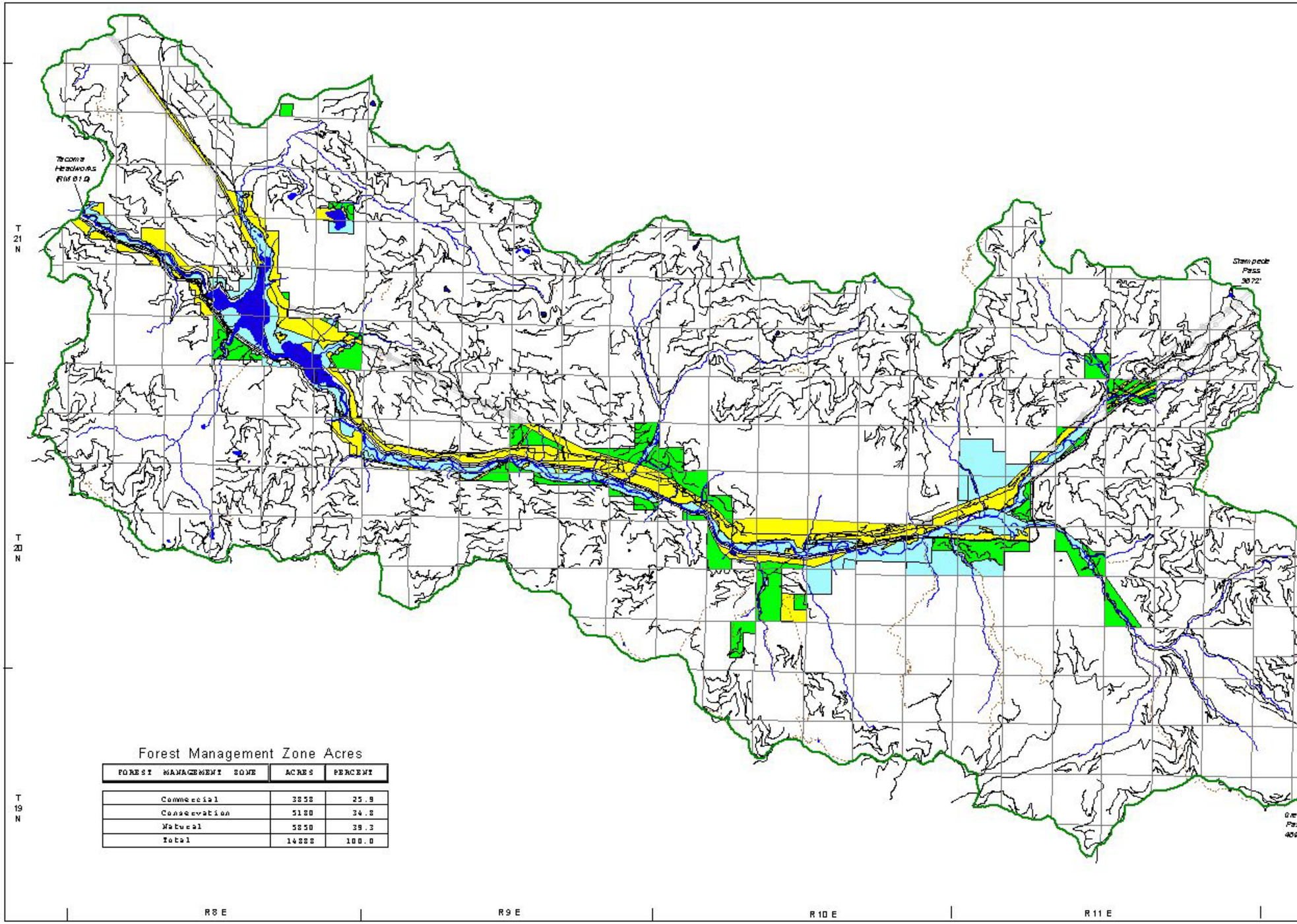


Forest Management Zone Acres

FOREST MANAGEMENT ZONE	ACRES	PERCENT
Commercial	3858	25.9
Conservation	5180	34.8
Natural	5850	39.3
Total	14888	100.0

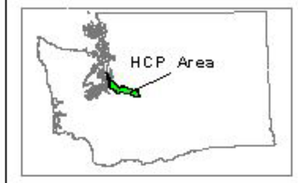


Figure 5 - 4.

Tacoma City Water
Green River Watershed
Forest Management Zones

Legend

- Upper Watershed Boundary
- Public Land Survey
- Railroad
- Road
- Trail
- Streams
- Water Body
- Commercial Zone
- Conservation Zone
- Natural Zone
- Pipeline
- Powerline

N

Scale = 1:126,720

1 0 1 2

Scale in Miles

1 inch = 2 miles

Source: Tacoma Water GIS

FIGURES

TABLES

5.2.2 Habitat Conservation Measure: HCM 2-02
Howard Hanson Dam Non-Dedicated Storage and Flow Management Strategy

HABITAT CONSERVATION MEASURE NUMBER: HCM 2-02

MEASURE: Howard Hanson Dam Non-Dedicated Storage and Flow Management Strategy

As local sponsor of the AWS project, Tacoma will support the USACE in developing an enhanced springtime operating strategy for HHD involving the management of dedicated and non-dedicated blocks of water to benefit fisheries resources. The maximum storage volume behind HHD is 106,000 acre-feet (ac-ft). The full storage volume is required to meet USACE flood control responsibilities in the winter months, but only a portion of the maximum storage volume is needed for flood control in the spring. Under the AWS project, up to 49,200 ac-ft of water will be stored behind HHD during the spring to meet fisheries and municipal and industrial water needs. The HHD springtime reservoir refill strategy will be required to always provide congressionally authorized flood control capacity behind HHD.

The USACE currently stores 24,200 ac-ft of water behind HHD between mid-March and early June for summer low flow augmentation for fisheries purposes. Storage of that block dedicated to low flow augmentation water was authorized during original development of the HHD project. Optional storage of up to 5,000 ac-ft of additional water dedicated to low flow augmentation is provided on an annual basis as part of the AWS project (use of this 5,000 ac-ft of water dedicated to aquatic resource needs is described in measure HCM 2-06). The AWS project also provides for storage of up to 20,000 ac-ft of water dedicated to municipal and industrial water supply use. The 20,000 ac-ft of water represents water available to Tacoma under the SDWR and is stored at a rate of up to 100 cfs per day within flow constraints measured at the USGS Auburn and Palmer gages as described in the MIT/TPU Agreement. Water stored behind HHD will be allocated as dedicated or non-dedicated blocks depending on whether the water is allocated to a specific purpose (e.g., water dedicated to municipal water supply or low flow augmentation) or is available for multiple use (non-dedicated).

Water that is stored and dedicated for municipal use will be available for use by Tacoma at any time. This stored municipal water represents a prior exercise of Tacoma's SDWR and its subsequent use and is not constrained by additional instream flow requirements. When Tacoma requests that stored municipal water be released from HHD, the USACE will comply with the request provided there is sufficient water remaining within the block of water dedicated to municipal use. When water is released from HHD at the request of Tacoma, the volume of water released for municipal use will be subtracted from the remaining municipal water storage account. Should Tacoma not use the stored water as it is released, whether through malfunction of Tacoma's facilities, excessive turbidity, or increased runoff associated with precipitation events. Tacoma's municipal storage account will be reduced by the volume of stored municipal water released.

The non-dedicated block of water can be managed in a variety of ways: released to meet immediate fishery resource needs; dedicated to low flow augmentation storage requirements; dedicated to municipal and industrial water supply to eliminate subsequent storage requirements; or held in reserve as non-dedicated storage to meet potential instream flow needs later in the spring. The non-dedicated storage volume is eliminated as the blocks of low flow augmentation and municipal water supply storage are filled. **Water that is released to the river from the non-designated block of storage (excess water or water needed by the USACE for the collection and handling of reservoir woody debris) from HHD is assumed to be fish conservation water. Fish conservation water shall not be diverted from the river by Tacoma.**

This non-dedicated block of water will provide resource agencies the opportunity to recommend adjusting the rate of storage and release during the refill season to benefit fisheries resources. Potential flow adjustments to benefit fish could include: 1) limits to the maximum rate of reservoir refill (the difference between the inflow and the outflow) to allow natural flow variations to aid downstream fish movement; 2) target instream baseflows to reduce side channel dewatering; 3) artificial freshets (short-term high flow releases from HHD) to speed the rate of downstream migrating salmonids; and 4) controlled long-term stage declines to protect steelhead redds. The magnitude, duration, and timing of each of these measures will be evaluated through a research program; changes to the refill and release strategy will be determined through an adaptive management process.

During the spring reservoir refill period, inflow to the reservoir may contain turbidity levels unacceptable for public water supply use. There has been a concern expressed by resource agency staff that Tacoma might request the USACE to both release the turbid water and subsequently dramatically curtail reservoir discharge in order to quickly refill the pool with clean water. Tacoma and federal and state resource agencies have developed a course of action and operational safeguards to minimize any potential adverse impacts to fish and wildlife resulting from the collection of a high turbidity pool.

In addition to reliance on the North Fork well field during high turbidity periods, Tacoma will utilize groundwater supplies to avoid the need to draw water from a turbid pool behind Howard Hanson Dam. During the preliminary engineering and design phase of the AWS project, Tacoma and the USACE will evaluate the potential risk of storing highly turbid water. If Tacoma is unable to be convinced that turbidity in stored water will settle by late May or early June, Tacoma will not proceed with the AWS project until filtration of the water supply can be achieved or until an alternative source of water supply has been developed to meet early summer municipal water needs. In the event that conditions were to occur that are currently unforeseeable, Tacoma agrees to take every effort to avoid actions which would be detrimental to the Green River's natural resources as the City attempts to meet its obligation to protect public health and safety through the supply of water. Tacoma would impose water use restrictions consistent with drought conditions and would coordinate with resource agencies and

the Muckleshoot Indian Tribe prior to requesting a modification of Howard Hanson Dam operations that might adversely impact Green River fisheries. Tacoma would not make such a request unless there was an imminent risk of violating Primary Drinking Water Standards along with the associated health risk of such a violation.

Objective

The objective of this measure is to support the development and implementation of a strategy for the operation of HHD that will provide maximum benefits to fisheries habitat, consistent with flood control and municipal water supply.

Rationale and Ecosystem Benefits

Howard Hanson Dam was originally authorized in 1958 and, since completed in 1962, has been operated by the USACE for flood control and downstream low flow augmentation. The HHD controls runoff from approximately 220 square miles of the Green River watershed and provides 106,000 ac-ft of reserve flood control volume to store watershed runoff. The maximum storage volume behind HHD is reserved for the storage of water during the peak flooding seasons, generally November through early February. Runoff from the upper watershed is impounded during storm events and released in a regulated manner to prevent flows in the Green River at Auburn from exceeding 12,000 cfs. After the impounded flows are released, the reservoir is emptied to provide storage for the next storm event. The full storage volume is required to meet USACE flood control responsibilities in the winter months, but only a portion of the maximum storage volume is needed for flood control in the spring. During the spring of each year, the reservoir is allowed to fill to provide water for low flow augmentation to meet the instream flow target of 110 cfs at Palmer. Since the construction of HHD, the springtime strategy of storing and releasing water has evolved. Additional information was developed on the effects of flow management on instream biological resources leading to changes in the springtime HHD operating regime.

HHD Operations: 1962 - 1983

The original authorization for HHD provided for the storage of 24,200 ac-ft of water at elevation 1,141 feet to be used for low flow augmentation for fisheries purposes. Prior to initiating summer refill, the project was operated in a run-of-river mode (i.e., HHD releases match HHD inflow). Although anadromous fish did not have access to the upper watershed prior to 1982, any fish moving downstream from the upper watershed during run-of-river operations passed quickly and safely through two large radial gates at the base of the dam at elevation 1,035 feet. When the radial gates were closed and the reservoir began filling, fish moving downstream were unable to use the radial gates to

pass downstream through the project. A 48-inch outlet pipe, located at elevation 1,069 feet and used for spring and summer flow releases of less than 500 cfs, provided the only available route for fish moving downstream. When the 48-inch outlet pipe became submerged by the rising pool level, fish moving downstream were either unwilling to sound to the outlet entrance and/or unable to find the outlet. Fish that were able to exit through the 48-inch outlet pipe suffered a high rate of mortality due to stresses caused by several 90-degree bends within the 48-inch conduit.

Beginning in 1982, juvenile anadromous salmonids were planted in the upper watershed. Although adult salmon had not been passed upstream of RM 61.0 since Tacoma's Headworks facility was completed in 1913, outplanting of juvenile salmonids was used to take advantage of upstream rearing habitat and to evaluate downstream passage through HHD. The original operational strategy for the HHD project, generally followed from 1962 to 1983, delayed the start of refill until June and thereby provided successful passage of downstream migrants through the radial gates. Once refill was initiated, nearly all inflow was stored and only water required to satisfy the instream flow target of 110 cfs at Palmer was released. Storing the water as quickly as possible minimized the duration, but exacerbated the magnitude of downstream impacts by dramatically cutting flows to the lower river once reservoir refill began. This refill strategy reduced flows from an average of 1,140 cfs at Auburn to a low flow of 234 cfs for an average 12-day period in early June (USACE 1995). This rapid rate of reservoir refill caused significant impacts to downstream fisheries, including the dewatering of steelhead redds throughout the lower river.

HHD Operations: 1984 - 1992

During the period between 1984 and 1992, the HHD operational strategy followed by the USACE generally consisted of initiating refill much earlier than the 1962-to-1983 practices to reduce impacts to steelhead redds, while also delaying refill as late as possible to facilitate downstream passage of juvenile outmigrants. Refill was started as early as 19 April. During refill, all inflow was stored except for releases to provide 200 cfs immediately below the Headworks. Although impacts of this strategy on steelhead redds were less severe than before, this practice was discontinued after 1991 (USACE 1995, HDR Engineering and Beak Consultants 1996).

HHD Operations: 1992 - Present

Beginning in 1992, the USACE operational storage strategy for HHD has involved periodic adjustments to meet a variety of resource needs. Releases from HHD are adjusted to account for changing inflow and weather conditions to provide additional

flows to benefit fisheries resources, with consideration for whitewater recreation opportunities and specific community activities (USACE 1995). Adjustments in the timing and rate of spring refill represent a compromise between the passage of juvenile outmigrants through the HHD reservoir and downstream fishery impacts. The refill strategy attempts to provide flows for steelhead spawning and incubation in response to expected weather and runoff conditions. Refill is started as early as mid-March to allow greater flexibility in achieving the full conservation pool at elevation 1,141 feet by early June. A relatively constant rate of refill of approximately 400 cfs is used to provide a more natural flow regime, and refill is initiated early to reduce the impacts of steelhead redd dewatering. This strategy involves frequent communication with members of the Green River Flow Management Coordination Committee. This interagency committee was formed in 1987 and consists of representatives from MIT, state, federal, and county resource agencies, and other groups. The USACE considers input from the group as an adaptive management strategy to adjust the refill and release regime based on a short-term planning horizon.

To date, the success of the adaptive management process has been limited by physical and operational project constraints. Storing water earlier in the year would provide added operational flexibility, but refill is constrained by the desire to pass downstream migrating fish through the project. Once the radial gates are closed, the rate of successful passage of downstream migrating juvenile salmonids through the HHD project drops dramatically.

The spring flow management regime is also limited by the need to reach the conservation pool by early June. The USACE manages reservoir refill and release to ensure that the 24,200 ac-ft of storage for low flow augmentation is achieved on a 98 percent reliability. Even if the Flow Management Committee recommends that refill be delayed, the USACE will override their suggestions to ensure the 24,200 ac-ft storage objective is not compromised. For example, during the spring of 1997, the committee recommended reservoir refill be delayed since the upper watershed was thought to contain an unusually high level of snowpack. Reservoir storage fell below the 98 percent refill rule curve and in late May the USACE temporarily reduced project releases to quickly fill the reservoir pool. The short-term increase in refill caused flow in the Green River at Auburn to drop from 3,230 cfs on May 19 to 900 cfs on May 27, before rebounding to 2,930 on June 2 (USGS 1997).

HHD Operations: Increased Storage under the AWS Project

As part of the AWS project, authorized uses of HHD will be expanded to provide ecosystem restoration benefits and municipal water supply. Up to 5,000 ac-ft of additional water would be stored for fisheries benefits and 20,000 ac-ft of water would be stored for municipal and industrial use. Under the SDWR, Tacoma can withdraw up to 100 cfs of water at its Headworks, provided instream flow requirements are satisfied at the Palmer and Auburn USGS gages as described in the MIT/TPU Agreement. Under the AWS project, instead of Tacoma withdrawing water at the Headworks between mid-February and late May, the USACE will store up to 20,000 ac-ft of water for Tacoma's municipal and industrial use. The summer conservation pool will be 1,167 feet and total 50,400 ac-ft of storage, which represents:

Storage Volume	Authorized Purpose
24,200 ac-ft	low flow augmentation (as part of original HHD authorization);
1,200 ac-ft	turbidity pool (non-active storage);
5,000 ac-ft	optional annual storage (AWS project fisheries benefits);
20,000 ac-ft	municipal and industrial use (AWS project municipal benefits);
50,400 ac-ft	total storage under the AWS project.

Integral to the adaptive flow management process associated with the AWS project is the need to forecast seasonal flow conditions and run-off in the Green River. During a spring drought with little snowpack, storage of 50,400 ac-ft of water represents over 35 percent of the total run-off measured at HHD (RM 64.5) between 15 February and 31 May (e.g., 1992 as estimated by the CH2M Hill daily flow model (CH2M Hill 1997). During a wet spring with high run-off conditions, storage of 50,400 ac-ft represents less than 10 percent of the total run-off measured at HHD (e.g., 1972 as estimated by daily flow model, CH2M Hill 1997). Forecasting flow conditions in the Green River basin requires reliable estimates of the volume of water stored as snow and ice in the upper watershed and the ability to forecast long-term weather patterns. Run-off forecasting is an imprecise science, but the reliability of forecasts will be improved with additional snowpack and precipitation monitoring stations in the upper Green River watershed (see Snowpack and Precipitation Monitoring Conservation Measure). Additional snowpack monitoring and improved runoff forecasting will benefit the reliability and flexibility of spring water storage and release.

During the spring reservoir refill period, inflow to the reservoir may contain turbidity levels unacceptable for public water supply use. There has been a concern expressed by

resource agency staff, that Tacoma might request the USACE to both release the turbid water and subsequently dramatically curtail reservoir discharge in order to quickly refill the pool with clean water. Tacoma representatives acknowledged this concern during a meeting with federal and state representatives in February 1999. During the meeting, a course of action and operational safeguards were established to avoid adverse impacts to fish and wildlife resulting from collection of a high turbidity pool.

Tacoma believes there is a low likelihood that a turbidity pool behind Howard Hanson Dam would cause a long-term public water supply operational problem. Tacoma has been advised by the USACE that turbidity problems which could occur during February, March, and in rare instances April, would clear up by late May or early June. This is a major issue for Tacoma since the continuing operation of their surface water supply as unfiltered depends in large part on their ability to provide the public with water that meets rigorous federal and state water quality standards. Tacoma will insist that additional evaluation of turbidity be conducted during the pre-construction engineering and design phase of the Howard Hanson AWS project. This additional evaluation will consist of hiring a consulting firm skilled in the evaluation of public water supply turbidity concerns to review the HHD operation and evaluate the nature of turbidity during high flow events on the Green River. If Tacoma is unable to be convinced that turbidity in stored water will settle by late May or early June, it would be forced to delay the AWS project until filtration of the Green River municipal water supply could be accomplished, or until an alternative source of supply to meet early summer municipal water needs has been developed.

Operationally, high turbidity periods on the Green River during the spring and early summer refill period would be accommodated through the use of Tacoma's groundwater sources in lieu of reliance upon Green River surface water. Tacoma currently has 72 million gallons per day (mgd) (113 cfs) of groundwater capacity from the North Fork Green River well field. Unfortunately, this full capacity is not available except for brief periods during the winter. It can never operate for a sustained period at 72 mgd. The only time the well field can produce 72 mgd without a water level decline is during heavy rainstorms. Aquifer storage capacity tails off during the summer and is at its lowest during the late summer and early fall. On the average, the North Fork well field has the following water supply capacities during the months when the Howard Hanson reservoir is being filled and turbidity is a concern:

North Fork well field sustained capacities (mgd) by month during Howard Hanson Reservoir refill operations (Source: Kirner, J. C. 1999. Letter to NMFS/USFWS/WDFW dated 26 March 1999, Tacoma Water, Tacoma Public Utilities, Tacoma Washington).

	February	March	April	May	June
mgd	48	36	24	24	24
cfs	75	56	37	37	37

In addition to reliance on the North Fork well field during high turbidity periods, Tacoma has groundwater supplies available in the Tacoma area. Tacoma's water rights in the vicinity of the City of Tacoma are approximately 90 mgd (140 cfs). This capacity, coupled with the water available from the North Fork well field, would meet Tacoma's demands for water in the event of a turbidity emergency on the Green River. Tacoma would rely on these two primary sources of groundwater to avoid the need to draw water from a turbid pool behind HHD.

In the event that conditions were to occur that are currently unforeseeable, Tacoma agrees to make every effort to avoid actions which would be detrimental to the Green River's natural resources as the City attempts to meet its obligation to protect public health and safety through the supply of water. Tacoma would impose water use restrictions consistent with drought conditions and would coordinate with resource agencies and the Muckleshoot Indian Tribe prior to requesting a modification of HHD operations that might adversely impact Green River fisheries. Tacoma would not make such a request unless there was an imminent risk of violating Primary Drinking Water Standards along with the associated health risk of such a violation.

Under the AWS project, reservoir refill could begin as early as mid-February, provided that available storage volumes for flood control are not compromised. The construction and operation of a downstream fish passage facility at HHD would provide for the downstream passage of outmigrating fish while allowing the reservoir to begin filling. The AWS project provides the opportunity to store water while managing downstream flows to benefit fish. However, maximizing those benefits requires a different approach to springtime flow management (described below) than has been used since 1992.

Potential HHD Operational Strategy: Dedicated and Non-Dedicated Storage

To minimize the effects of storing additional water behind HHD during the spring, Tacoma initiated an intense modeling effort using a 32-year record of daily flows to evaluate alternative reservoir refill strategies. This process resulted in the proposed management plan involving the use of dedicated and non-dedicated blocks of water. The

rate of water storage would be accelerated early in the spring before the majority of juvenile salmonids have begun their downstream migration. Storage would be completed by mid to late May to avoid impacts to steelhead redds. The accelerated rate of water early in the refill season would establish a block of non-dedicated storage. The volume of water in non-dedicated storage would be managed in response to input from the Green River Flow Management Committee (GRFMC).[1] The non-dedicated block of water could be used to meet a variety of fishery needs, including:

- augmenting HHD releases during short-term low flow periods in March, April and May;
- augmenting HHD releases during late May and June to protect steelhead incubation;
- suspending HHD storage during storm events to allow freshets to pass; or
- in the absence of a natural freshet, providing a short-term release of high flows to aid downstream migrating salmonids.

In the course of Tacoma's modeling efforts, an initial AWS project flow management strategy was developed that attempted to balance the needs of fisheries and water storage. This strategy ensured refill of the conservation pool while meeting a variety of fisheries protection standards. If implemented, the effects of this strategy would be monitored (see

[1] Recommendations on the storage and release of water from Howard Hanson Dam will be developed through the USACE's coordination with the Green River Flow Management Committee (GRFMC). The GRFMC consists of representatives of tribal and natural resource agencies convened by the USACE to recommend adaptations in the water storage and release regime of Howard Hanson Dam. Responsibility for operation of Howard Hanson Dam lies with the USACE. The USACE, in turn, must comply with project purposes as identified by congressional authorization and must abide by NMFS and USFWS direction through Section 7 consultation under the Endangered Species Act.
The GRFMC consists of representatives from the:

USACE	U.S. Army Corps of Engineers;
NMFS	National Marine Fisheries Service;
USFWS	U.S. Fish and Wildlife Service;
MIT	Muckleshoot Indian Tribe;
WDFW	Washington State Department of Fish and Wildlife;
Ecology	Washington State Department of Ecology;
King County	King County Department of Natural Resources; and
Tacoma	Tacoma Public Utilities, Tacoma Water.

Representatives from other groups; such as Trout Unlimited and Friends of the Green River have participated in past meetings of the GRFMC. It is up to the USACE, and ultimately the NMFS and USFWS to determine the degree of influence of each member of the GRFMC.

Chapter 6) and adjustments implemented under the recommendations of the GRFMC. Fisheries protection standards and potential flow adjustments include: maximum refill rates; target baseflows; and the release of artificial freshets if deemed beneficial by the GRFMC. These potential flow adjustments are further described below:

Maximum Refill Rate. Under Phase I of the AWS project, the 400/300/200 flow management strategy modeled using the 32-year record of daily flows includes a maximum refill rate of:

- **192** cfs per day (5,000 ac-ft maximum) from 15 February through 28 February,
- **400** cfs per day (800 ac-ft per day) in March,
- **300** cfs per day (600 ac-ft per day) in April, and
- **200** cfs per day (400 ac-ft per day) from May through June.

Outmigration studies conducted at HHD in 1984 and 1991-1995 show that inflow, outflow, and refill rate all influence successful smolt outmigration (Dilley and Wunderlich 1992, 1993). In general, it is thought that higher flows through the HHD result in faster smolt migration through the project and higher smolt survival. To date, empirical data have been collected that have evaluated smolt travel times occurring with fill rates up to 400 cfs per day. Further studies are needed to more fully determine the overall effects of different refill rates. Such studies should lead to the identification of those rates that maximize passage success of juveniles through the bypass facility. The timing associated with the different rates reflects the concept of initiating reservoir refill prior to the peak of smolt outmigration, and while refill should be aggressive, the maximum rate should be limited to provide variation in stream flow while reducing the incidence and magnitude of side channel dewatering.

During 1999 **and 2000**, the USACE in response to requests from the GRFMC, has attempted to store a percentage of inflow rather than a **daily** fixed volume of water. This alternative storage refill strategy holds promise for benefiting both fishery and water storage needs. The strategy of storing a percentage of inflow will be further evaluated during the preliminary and engineering design phase of the AWS project.

Target Baseflows. The proposed instream baseflow targets for the Green River at Auburn based on Tacoma's modeling efforts for refill of the HHD reservoir are:

	Flow Condition		
Month	Wet	Average	Dry
15-28 February	900	900	900
March	900	750	575
April	900	750	575
May through 1 July	linear drop 900 to 400	linear drop 750 to 400	linear drop 575 to 250

Modeling of daily flows over the 32-year period of 1964 to 1995 suggests these target baseflows can be maintained while meeting other fisheries protection standards such as refill rates and freshets. These baseflow targets are goals rather than commitments and can be adjusted based on changes in weather patterns, results of monitoring efforts, and input from fishery resource managers. These target instream flow levels are much higher than the low flow levels that have been previously associated with HHD refill and should benefit downstream fisheries.

From February through June, salmonid fry are emerging and rearing in shallow mainstem channel margins and side channel habitats of the Green River. Off-channel habitats (i.e., side channels, sloughs) are thought to be vital components of salmonid production in Pacific Northwest rivers (Bustard and Narver 1975; Sedell et al. 1984; Beechie et al. 1994). Peterson and Reid (1984) estimated that, annually, 20 to 25 percent of the total smolt yield in the Clearwater River, Washington, comes from side channel habitat. In British Columbia, approximately 16,000 juvenile coho salmon overwintered in a side channel in the upper Squamish River (Sheng et al. 1990). Cowan (1991) found that five groundwater-fed side channels on the East Fork Satsop River, Washington, produced between 19 and 71 chum fry per square foot of channel area. Swales (1988) hypothesized that side channels supplied higher water temperatures **in the winter** due to groundwater inflow and provided greater food availability, which increased overwinter survival of juvenile coho when compared to the mainstem habitats in the Fraser and Keough rivers, British Columbia. A total of 59 side channel areas were identified in a survey of the middle Green River in 1996 (USACE 1998). Side channels in the Green River provide spawning and/or rearing habitat for all Green River salmonids and, for chum salmon, may provide the majority of spawning habitat (Coccoli 1996). Short-term flow reductions can isolate side channel habitat from the mainstem channel and cause mortality by trapping juvenile salmonids and exposing them to predation, poor water quality, or reduced food supply.

During the spring, juvenile salmon and steelhead are migrating downstream to the estuary. Many researchers believe there is a general positive relationship between flow

and outmigrant survival, although the relationship appears to vary widely for different species under different environmental conditions. In the Green River, researchers in the late 1960s conducted experiments using marked releases of hatchery chinook salmon (Wetherall 1971). They identified a general trend associating increased smolt survival with increased flow in the lower river. Maintaining higher baseflows is assumed to benefit outmigrant survival by increasing their rate of migration through the HHD reservoir and lower mainstem river.

Artificial Freshets. In order to evaluate the range of flexibility afforded by this habitat conservation measure, the daily flow regime was modeled to include the release of two freshets during the spring. The freshets would be timed for April and May to aid downstream migrating salmonids and to temporarily re-connect side channels. Each freshet is assumed to be a maximum flow of 2,500 cfs for 38 hrs at the Auburn, Washington, gage during normal years, and 1,250 cfs for 38 hrs during dry years. The magnitude and duration of the artificial freshets was identified through analysis of water travel times associated with HHD releases as part of the AWS project (USACE 1998). Recommendations on timing, magnitude, duration, and need to release non-dedicated storage as a freshet would be made by the GRFMC based on the results of monitoring.

Side channels and sloughs provide the majority of chum salmon spawning habitat in the Green River (Coccoli 1996). Isolation of these side channels can increase chum mortality by trapping fry that would otherwise be migrating downstream to the estuary. Chum salmon typically migrate within several days to weeks following emergence. Chum fry that have emerged in side channels but are isolated by low water levels may not survive unless they have access to the mainstem channel.

Past reservoir refill operations have stored or captured naturally occurring short-term fluctuations in flow, also referred to as freshets. In some years, this has resulted in a flat or constant outflow rate during reservoir refill. Results of outmigration studies in the Green River have shown that a sharp increase in flow can stimulate increased downstream movement of smolts (Dilley and Wunderlich 1992, 1993). In the upper Snake River, Idaho, researchers found that a two-fold increase in flow increased the migration rate by eight to 12-fold for hatchery chinook, 3.5- to 4.6-fold for wild chinook salmon, 1.6- to 2.1-fold for hatchery steelhead trout, and 2.4-fold for wild steelhead (Buettner and Brimmer 1996). Knapp et al. (1995) concluded that the initial rise in flow appeared to push fish out, but that sustained fish movement was not positively correlated with prolonged high flows; pulsing water releases appeared to increase the effectiveness of moving fish out of the lower Umatilla River, Oregon. Outmigration studies in the

Stanislaus River, California, revealed that a pulse in flow from the release of stored water stimulated a substantial increase in juvenile chinook outmigration. However, increases in fish movement lasted only a few days following an increase in releases of stored water (Demko 1996).

Summary and Example of Proposed Flow Management Strategy using 1995 Daily Flows

Collectively, these flow management measures are intended to help minimize the effects of the USACE storage and release of water at HHD on fishery resources. The HHD downstream fish passage facility allows storage of springtime water much earlier than under existing conditions, while enhancing the downstream passage of salmonid smolts through the HHD project. These features allow reservoir refill to begin earlier than previous HHD management regimes and provide for the use of dedicated and non-dedicated blocks of storage. An example of how the proposed management strategy would be implemented using the 1995 daily flow record (average runoff conditions) is provided in Figure 5-2. For comparison purposes, flows in the Green River at Auburn under the proposed adaptive management regime are plotted with the flow regime that would have occurred under a storage regime involving a constant capture of 237 cfs. A constant rate of 237 cfs of storage between mid-February and 31 May would meet the storage target volume and allow natural flow variations to persist through the downstream reaches.

The level of water stored in the various dedicated blocks of water under the 400/300/200 storage refill strategy using 1995 flows are shown by time interval in Figure 5-3. Note that although different blocks of water are described, it simply represents an accounting convention. All water is stored in the single pool behind HHD. By the end of the storage period, water has either been dedicated to specific use (low flow augmentation or municipal water supply) or released to meet downstream needs. The use of the non-dedicated storage block is discontinued by the end of the spring storage period.

February

As previously described, storage of water would begin on 15 February; however, in this example the rate of storage is limited to 108 cfs during February, due to flood control concerns. As shown in the accompanying figure, by 28 February nearly 2,700 ac-ft of water would be held as dedicated storage for municipal water use at the rate of 100 cfs per day. Water held as dedicated storage for municipal use represents that volume available to Tacoma under the SDWR as constrained by the MIT/TPU Agreement. This scenario assumes that 100 cfs per day would be available under the SDWR for the entire

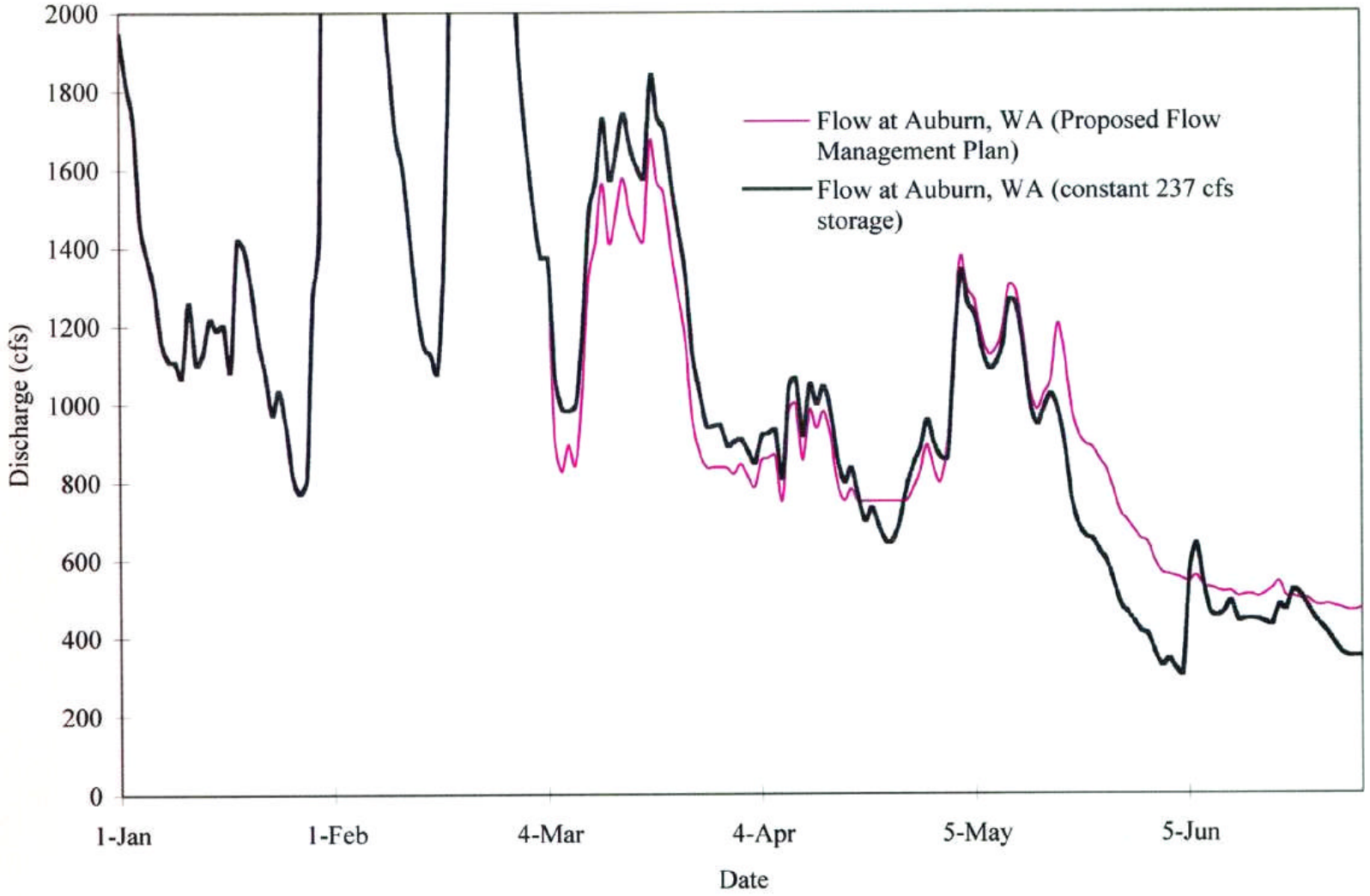
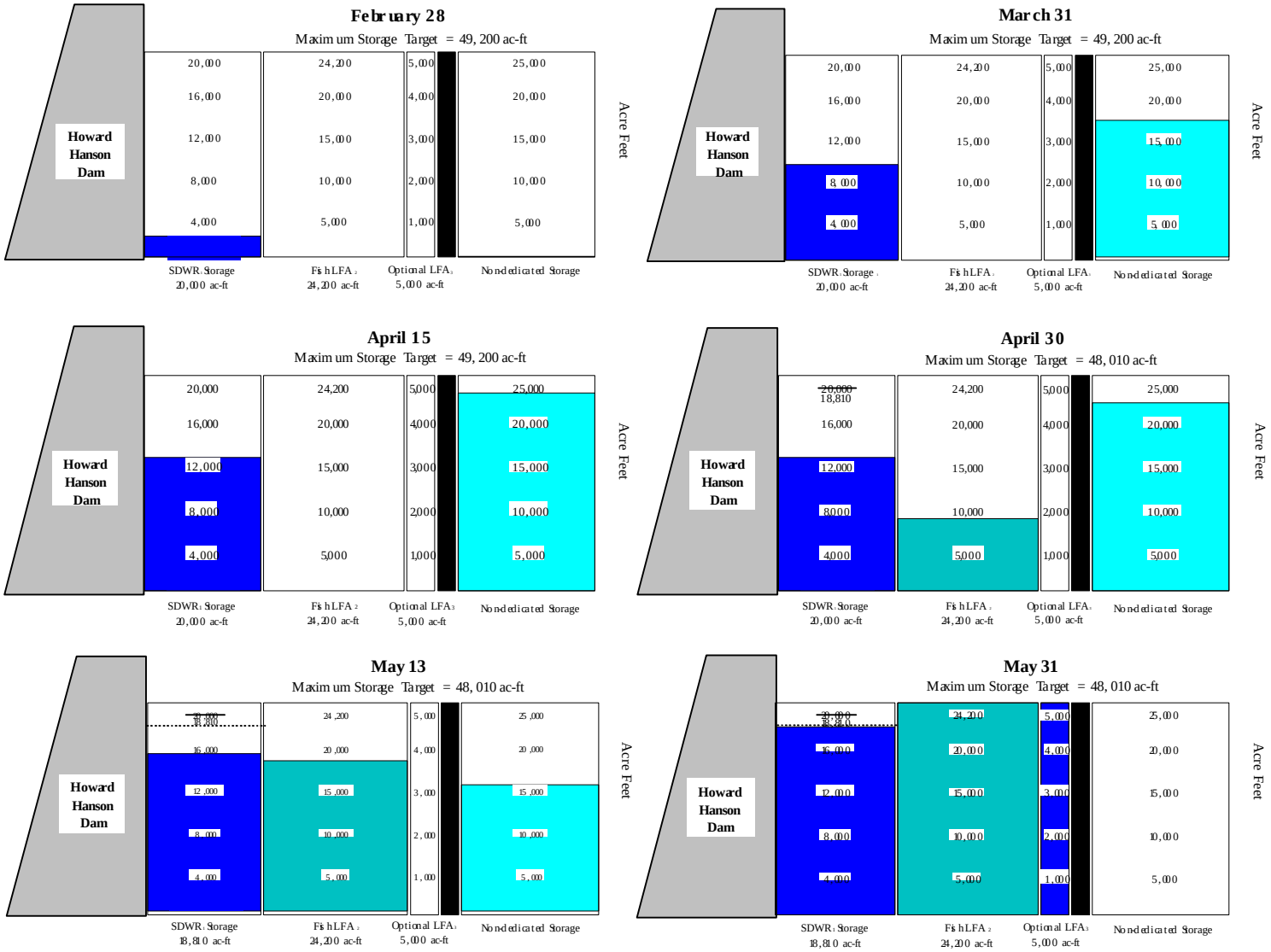


Figure 5-2. Comparison of Green River flows (cfs) at Auburn, WA (USGS Gage No. 12113000) during 1995 under flow management regime proposed for the AWS project (USACE 1998) and a 237 cfs constant storage regime.



1 Second Diversion Water Right (SDWR) allows Tacoma to withdraw water up to 100 cfs per day depending on flow rates ~~at Palmer gage~~.
2 24,200 ac-ft of water is stored to augment low flow in the Green River, storage of the water was authorized with the construction of HHD.
3 Optional storage up to 5,000 ac-ft.

Figure 5-3. Maximum storage volumes in Howard Hanson Reservoir, Washington, 1995.

14-day period. The non-dedicated block of storage would hold approximately 300 ac-ft of water.

March

During March, the rate of reservoir refill would be increased to 400 cfs and the majority of storage would be held as the non-dedicated block of water. During this period, flows in the Green River would occasionally dip 100 cfs lower than under the constant storage regime but would still be above 800 cfs. By the end of March, the block of water dedicated to municipal use would hold 8,900 ac-ft. Water held as dedicated storage for municipal use represents that volume available to Tacoma under the SDWR as constrained by the MIT/TPU Agreement. Under the terms of the Agreement, Tacoma can exercise the 100 cfs SDWR when flows in the Green River exceed minimum flow requirements of 300 cfs at the Palmer gage site. This scenario assumes that 100 cfs per day would be available under the SDWR for the entire month. The non-dedicated block of water would hold nearly 18,000 ac-ft. No water would need to be dedicated for the low flow augmentation block during March since storage under the USACE 98 percent refill guide curve does not begin until 16 April.

April

During April the refill rate would be reduced to 300 cfs under the 400/300/200 flow management strategy. Flow in the Green River at Auburn under the proposed management plan would drop to 750 cfs in early April and remain about 100 cfs lower than would have occurred under the constant 237 cfs storage regime. In late April, however, flows under the constant storage regime would have dropped below 650 cfs. Under the 400/300/200 strategy, a portion of the non-dedicated storage would have been released to augment flows and ensure flows do not drop below 750 cfs. If, during this naturally occurring low flow period, flow in the Green River drops below the flow requirements allowing withdrawal/storage of water under the SDWR, the municipal storage target would be reduced by 100 cfs for each day that withdrawals would not have been allowed under the MIT/TPU Agreement. On the days that SDWR withdrawals would have been constrained by low flows in the Green River, no water would be dedicated to municipal use. Assuming SDWR withdrawals would have been disallowed for 6 days, the total municipal storage target would be reduced from 20,000 ac-ft to 18,810 ac-ft. By the end of April, approximately 13,700 ac-ft of water would be dedicated to municipal use, and 9,000 ac-ft would be dedicated to low flow augmentation. Approximately 22,000 ac-ft of water would be held as non-dedicated storage.

May

Under the proposed flow management strategy, reservoir refill would be reduced to 200 cfs in May. By 13 May, total reservoir storage would be 48,010 ac-ft. Sufficient non-dedicated water would be held to completely fill municipal and low flow storage requirements, including optional storage of 5,000 ac-ft. The GRFMC would have the option at this point to recommend releasing some of the water as a freshet, to parcel the water out to maintain higher baseflows, or to dedicate the water to municipal or low flow augmentation blocks. If water is released to meet downstream needs, the 200 cfs rate of reservoir refill (interception of inflow) would continue until the municipal and low flow augmentation storage blocks are filled. If water available in the non-dedicated block is transferred to completely fill the municipal and low flow augmentation storage needs, then storage of additional water would cease and use of the non-dedicated storage block would be discontinued.

Under the proposed flow management strategy, the baseflow target during the period 1 May through 1 July is a gradual linear decline from 750 cfs to 400 cfs. Green River flows at HHD would be augmented to maintain the baseflow target at Auburn. The intent is to maintain flow levels that benefit incubating steelhead redds as the flow regime gradually declines as spring progresses into summer. Under this scenario, flows in the Green River would be more than 200 cfs higher than what would have occurred under the 1996 refill regime. Instead of flows dropping to 305 cfs in early June, the proposed management regime maintains an instream flow of more than 500 cfs.

Summary

Past operation of Howard Hanson Dam has been constrained by the structural limitations of project facilities constructed in the early 1960s and by the USACE's precise implementation of congressionally authorized project purposes. As local sponsor of the Howard Hanson Dam-Additional Water Storage Project, Tacoma is supporting the USACE's efforts at developing operational procedures based on adaptive management to improve the protection of fisheries resources. The construction of a downstream fish passage facility will improve physical water control capabilities at HHD and implementation of a dedicated/non-dedicated flow management strategy will aid in the development of improved operational flexibilities. The increased opportunity for flow management is designed to partially offset the impact of Tacoma's use of the Green River for municipal water supply.

As part of the Howard Hanson Dam AWS project, the USACE will store water that is available to Tacoma for municipal use under the Second Diversion Water Right (SDWR).

Following construction of the AWS project, up to 100 cfs of water (198.2 ac-ft per day) will be stored behind HHD beginning in mid-February and dedicated for use by Tacoma. The municipal water storage rate of 100 cfs reflects Tacoma's exercise of the SDWR as constrained by limitations identified in the 1995 MIT/TPU Agreement. Storage of water for municipal use will continue until the maximum municipal storage volume of 20,000 ac-ft is achieved (minimum of 101 days or 26 May). The daily storage of 100 cfs represents a flow limitation of the AWS project, and the increased reservoir storage volume presents a potential delay or barrier to salmon fry moving downstream from the upper watershed.

Water in excess of that dedicated to Tacoma's municipal use (100 cfs) will be available for storage or release under the recommendations of the GRFMC. The maximum refill rate of the Howard Hanson reservoir has been tentatively identified as 400 cfs in March with a lower refill rate in other months. An alternative refill strategy, based on a percentage of reservoir inflow, is also being considered as a future storage regime. Under either storage regime, the volume of water stored in excess of that dedicated to municipal use can represent the majority of the HHD storage volume by the end of March. Under the proposed dedicated/non-dedicated flow management strategy, the USACE will consider the recommendations of the GRFMC before implementing flow management changes. The USACE is responsible for operation of Howard Hanson Dam and will consider input from the GRFMC, but must also comply with project purposes as identified by congressional authorization. Due to the recent listing of chinook salmon as a threatened species, USACE operations must now respect the direction of the NMFS and USFWS through Section 7 consultation under the Endangered Species Act. While the daily storage of up to100 cfs of water dedicated to municipal use reflects a limitation of the AWS project; increased operational flexibility is the cornerstone of the dedicated and non-dedicated flow management process.

Under the AWS project, structural changes to HHD, partially funded by Tacoma will provide increased operational flexibility. Examples of increased operation flexibility include: an earlier storage start date; increased control of rate of refill and release; reservoir surface release instead of bottom release; increased storage capability; and improved fish passage survival at HHD. These structural modifications allow the operational flexibility, which is required for the dedicated/non-dedicated flow management strategy. Under this proposed strategy, water in excess of the 100 cfs dedicated to municipal use can be used to meet immediate downstream fishery resource needs; dedicated to low flow augmentation storage requirements; dedicated to municipal storage to reduce subsequent storage requirements; or held in reserve as non-dedicated

storage to meet instream needs later in the refill season. The non-dedicated storage volume is gradually eliminated as the blocks of low flow augmentation and municipal water supply storage are filled.

The proposed flow management strategy has been developed within the framework of an adaptive management program. Key elements of the program include experimentation monitoring, analysis, and synthesis of results, followed by changes to the reservoir storage and release regime and continued monitoring and analysis. The proposed adaptive management program ensures that as additional information is developed, flows can be managed to minimize the detrimental effects of past and ongoing human perturbations and complement basin-wide restoration activities. Ongoing efforts by the USACE and King County, as part of the Green**/Duwamish Ecosystem** ~~River~~ Restoration Project, may provide new opportunities to restore ecological functioning of the Green River. In the face of imperfect knowledge, the proposed adaptive management program provides the greatest chance for the conservation and recovery of threatened and endangered species.

The opportunity to manage flows in the Green River for fisheries benefits is greatly increased under the proposed flow management strategy. However, identifying the effects of alternative flow management strategies will require research of fishery resources during the initial years of project operation. As local sponsor of the AWS project, Tacoma has committed to providing a research fund as described on Chapter 6.

5.2.3 Habitat Conservation Measure: HCM 2-03 Upper Watershed Stream, Wetland, and Reservoir Shoreline Rehabilitation Measures

HABITAT CONSERVATION MEASURE NUMBER: HCM 2-03

Measure: Upper Watershed Stream, Wetland, and Reservoir Shoreline Rehabilitation Measures

Tacoma will contribute funds for a series of habitat rehabilitation projects in the upper Green River as mitigation for inundation of additional reservoir area resulting from Phase I of AWS project. Project numbers assigned to each activity by the USACE are listed in parentheses. Projects to be funded by Tacoma under this HCM **are described below** ~~include~~:

Riparian and Stream Habitat Rehabilitation – In Reservoir

Mainstem and North Fork Channel Maintenance (MS-02; TR-04). These projects will maintain instream habitat and bank stability along the mainstem Green River and the North Fork Green River in the new inundation pool. Project features include: ~~1) placement of boulders to maintain bank stability in the existing channel; 2~~**1**) addition of large woody debris to create cover for fish; **2) placement of large boulders in select locations to maintain bank stability;** 3) excavation of sub-impoundments, off channel ponds, side channels, and dendrites. In addition, inundation tolerant vegetation will be planted along stream channels within the new inundation zone (1147 to 1177 feet MSL)

Tributary Stream Channel Maintenance (TR-05). This project will involve planting of inundation tolerant vegetation and placement of boulders and LWD within the newly inundated areas of Charley, Gale, Cottonwood, and MacDonald creeks.

Page Mill Pond Mitigation and Protection (VF-05). This project will maintain and improve an existing wetland pond complex within the floodplain of the North Fork Green River within and above the new inundation pool. A series of small ponds will be excavated in the floodplain of the existing pond complex. Native wetland plants will be planted above the new inundation pool, and inundation tolerant plants will be planted within the new pool. LWD will be placed in the ponds, at the pond outlet and in Page Mill Creek.

Lower Bear Creek (TR-01). This project site includes the lower 3,000 feet of Bear Creek, a large tributary that enters the Green River just below HHD at RM 63. Stream channel habitat will be rehabilitated by adding LWD and boulders, in conjunction with limited excavation to recreate meanders and backwater habitats. **This project site was identified in the Draft EIS for the AWS project as a potential conservation measure to offset impacts of reservoir inundation (USACE 1998). During 2000, the USACE, in coordination with the Services, considered replacing AWS project measure TR-01 with an alternative measure involving placement of LWD in the mainstem Green River. The USACE believes that placement of large woody debris will provide superior environmental benefits to the Lower Bear Creek measure as originally envisioned.**

Stream Habitat Rehabilitation - Above Reservoir

Abandoned Mainstem Channel at RM 83 (MS-04). A series of LWD jams will be constructed to re-route flow back to the natural channel in the mainstem Green River between RM 83 and RM 84. Currently, the river has abandoned its historic channel and is eroding the old Lester Airstrip and a mainline road adjacent to the river.

Mainstem LWD Placement (MS-08; TR-09). This project will involve placement of clusters of large trees approximately every 0.5 mile between RMs 71.3 and 80.3 in the mainstem Green River; in 4,600 feet of the North Fork Green River between elevation 1,240 MSL and 1,320 MSL; and in 1,200 feet of Gale Creek between elevation 1,240 MSL and 1,280 MSL.

The final design of these conservation measures will be developed during the pre-construction engineering and design (PED) phase of the AWS project. Large woody debris frequency and size requirements appropriate for the channel type will be determined using habitat criteria such as those recommended by the Washington Watershed Analysis Manual (WFPB 1997) or comparable systems approved by the Services.

Alternate measures will be implemented if any of the above measures are determined to be infeasible, or not cost-effective during the final design, or if environmentally superior measures can be implemented at comparable cost. Any alternate measures will have habitat benefits greater than or equal to the measure originally proposed, and will be reviewed and approved in advance by the NMFS and USFWS.

Objectives

The objective of this measure is to rehabilitate and/or enhance fisheries habitat in the Green River and its tributaries above HHD.

Rationale and Ecosystem Benefits

Riparian and Stream Habitat Rehabilitation – In Reservoir

Implementation of the AWS project will result in the inundation of additional areas habitat in the mainstem Green River and lower segments of a number of tributaries, including the North Fork Green River, Gale Creek, and Page Creek. The inundation will convert the lower segments of the streams from riverine to lacustrine (lake) type habitat on a seasonal basis. Rehabilitation activities included in this HCM focus on the inundated portions of major tributaries and on existing off-channel rearing sites or nearby highly impacted reaches.

Wildfires burned much of the riparian area in the upper Green River basin early this century, and, in combination with more recent flooding, mass wasting, and timber harvest, are believed to have reduced levels of in-channel LWD and increased deposition of coarse sediment (USFS 1996). The existing LWD frequency is currently less than the 2 pieces per channel width recommended for channels with "good" habitat conditions (WFPB 1997) in the majority of channels surveyed.

Riparian management zones within the natural zone are currently composed primarily of coniferous timber 60 to 90 years of age, and are just reaching the age that they would begin to contribute functional LWD. The riparian management conservation measures are intended to maintain or restore long-term LWD recruitment as stream adjacent stands

of timber mature. This conservation measure will provide immediate benefits in the form of increased instream structure and creation of additional off-channel rearing and refuge habitats. The conceptual designs of specific projects to be implemented are described below.

Mainstem and North Fork Channel Maintenance. Approximately two miles of habitat in the mainstem Green River and North Fork Green River will be inundated with the additional pool raise. Existing trees within the inundated riparian zones will be retained as described in the Standing Timber Retention HCM. Under this HCM, bare areas in and along the new seasonal inundation zone will be planted with vegetation that tolerates inundation and boulders, and LWD will be placed to create cover for fish. Planting sedges will protect newly inundated portions of the reservoir from erosion that results from wave action and provide some littoral cover for juvenile fish. It is expected that boulders (b axis >3 feet) will be placed at a rate of 30/1,000 feet (300 total) and LWD (>12 inch diameter and at least 20 feet long) will be placed at a rate of 40 per 1,000 feet (400 total). At least 25 percent of the pieces will be of sufficient volume to meet the requirements for key pieces. If key size pieces are not available, LWD will be clumped and anchored to promote stability.

Ponds, side channels, and dendrites will be excavated in the floodplain adjacent to the mainstem and North Fork Green River to increase the quantity of off-channel habitat available when the pool is full. Tentative mainstem off-channel habitat locations include a 1,400 foot side channel on the left bank at elevation 1,153 feet MSL; two small sub-impoundments on the right bank at elevations 1,156 and 1,158 feet MSL respectively; one side channel or two small sub-impoundments on the right bank at elevation 1160 MSL; and one 600-foot side channel and plus two sub-impoundment on the left bank at elevation 1163 MSL. Two 300-foot long side channels and two beaded ponds will be developed on the North Fork Green River.

Tributary Stream Channel Maintenance. Approximately one mile of habitat will be inundated in Charley, Gale, Cottonwood, Piling, and MacDonald creeks with the additional pool raise. Bare areas in and along the inundated streams will be planted with vegetation that tolerates inundation. Large boulders (b-axis > 3feet) will be placed in the inundated areas at a rate of 40 per 1,000 feet (165 total). LWD will be placed in the inundated areas at a rate of approximately 2 pieces per channel width (220 pieces total). Placement of LWD and boulders will increase habitat complexity within the inundated areas.

Page Mill Pond Mitigation and Protection. Three new ponds will be created in the existing pond wetland complex located near RM 2 on the North Fork Green River where seepage from the North Fork aquifer creates a tributary stream known as Page Mill Creek. The ponds will be excavated from the valley floodplain and log weirs installed as outlet controls. Approximately 20 acres of wetland plants will be planted, and 150 pieces of LWD (at least 12-inch diameter and 20-feet long) will be placed in Page Mill Creek and the new ponds.

~~***Lower Bear Creek.*** Lower Bear Creek was degraded by construction of Howard Hanson Dam and re-alignment of the railroad (USACE 1998). Boulders and LWD will be placed in the 300 feet of channel between the railroad bridge and the mainstem Green River to confine the channel and increase pool depth and bank stability. Structural placement is expected to consist of approximately 60 boulders with a diameter (b-axis) greater than or equal to 3 feet, and approximately 100 pieces of LWD, to establish an overall LWD frequency of 2 pieces per channel width. Selected portions of the channel will be excavated to create meanders and approximately ten 50-foot long backwater channels. An additional 50 pieces of LWD will be placed in these channels to improve the quality of the created habitat. Riparian habitat will be improved by selectively removing hardwoods to open the canopy, and planting a variety of coniferous tree seedlings.~~

Stream Habitat Rehabilitation - Above Reservoir

Abandoned Mainstem Channel at RM 83. Between RM 83 and RM 84 the Green River has abandoned its historical channel and begun eroding a road adjacent to the river. The new channel is shallow, braided, and has few pools. The former channel has an intact riparian zone, stable banks, and more natural channel morphology. Flow will be diverted back to the historic channel using debris jams and deflector logs. Each debris jam will contain at least one key-sized piece of LWD. In addition, 50 pieces of LWD will be placed in the historic channel. Each piece of LWD will be at least 12 inches in diameter and 20-feet long.

Mainstem LWD Placement. This project is designed as partial mitigation for the area of channel inundated by the AWS project pool raise. Between RM 71.3 and 80.3 in the mainstem Green River, clusters consisting of three or four large trees with attached rootwads (at least 60-feet long; rootwads ≥ 4-feet diameter) will be placed approximately every 0.5 miles. Key piece size LWD will also be added to Gale Creek and the North Fork Green River at the rate of one cluster per 0.5 miles of habitat. Clusters will be placed within the channel with rootwads facing upstream, or along the low-flow channel margins. Placement of clusters along channel margins is expected to promote the

formation of lateral and bar apex jams as additional wood collects on the clusters. Lateral log jams that collect at the outside of meander bends are a common natural structure in streams with bankfull widths greater than 65 feet (Slaney et al. 1997). Bar apex jams form when a single key-size piece with attached rootwad deposits oriented nearly parallel to flow and smaller pieces of LWD oriented roughly perpendicular to flow collect on the upstream side of the rootwad. This type of jam is common in large, meandering alluvial rivers (Abbe and Montgomery 1996). Assuming that the average frequency of key-size pieces in large channels is comparable to that observed in smaller channels (i.e., 0.25 pieces per channel width), the target number of key pieces per mile for the mainstem Green River was determined to be seven.

Unless state-of-the-art science suggests otherwise, LWD specifications will call for establishing LWD frequencies of approximately two pieces per channel width in side channels, and in channels less than 65-feet wide (WFPB 1997). Target LWD frequencies in larger channels are less well documented. LWD generally collects in clusters within larger channels in channels greater than 65-feet wide (Slaney et al. 1997), and is often associated with large key pieces. Approximately 25 percent of the LWD placed in larger channels will be key piece sized (volume $\geq$11 yd^3) if such pieces are available; if individual pieces large enough to function as key pieces are unavailable, LWD will be placed in clusters that have a minimum collective volume of 11 yd^3. LWD must be fir, hemlock, cedar, or spruce. Non-key piece sized logs will have a minimum diameter of 12 inches and be at least 20-feet long. Rootwads will have a diameter of at least 18 inches at the base of the bole, and a stem that is at least 3-feet long. If future studies or monitoring indicate that such LWD clusters are unstable in channels such as the mainstem Green River, LWD may be anchored pending approval of the services and USACE.

5.2.4 Habitat Conservation Measure: HCM 2-04 Standing Timber Retention

HABITAT CONSERVATION MEASURE NUMBER: HCM 2-04

MEASURE: Standing Timber Retention

Tacoma will retain 229 acres of existing standing timber within the new inundation zone of Howard Hanson Reservoir (1,147 feet to 1,167 feet) resulting from additional water storage under Phase I of AWS project. Any lands within the inundation area not under Tacoma or USACE ownership will be acquired by Tacoma prior to construction of the AWS project.

Decay of vegetative material in the newly inundated zone may cause water quality problems in water stored behind HHD for municipal use. Such problems are likely to be the result of the decomposition of grasses and low lying brush

with retained standing timber adding a minor impact. In the event that such conditions are determined likely to occur, Tacoma agrees to take every effort to avoid actions which would be detrimental to the Green River's natural resources as the City meets its responsibility to maintain water quality and protect public health. In the event of potential contamination of the municipal water supply, Tacoma will consult with the USFWS and NMFS to determine a course of action that will minimize impacts to Green River natural resources.

Objective

The objective of this measure is to accelerate the re-establishment of anadromous fish use of the Green River above HHD if acceleration is found to be beneficial.

Rationale and Ecosystem Benefits

The retention of standing timber (166 acres deciduous forest, 48 acres mixed forest, 15 acres conifer forest) in the HHD inundation zone would create standing snags in an area that would not otherwise support live vegetation. The standing snags would maintain wildlife, riparian, and instream habitat through periods of reservoir inundation. In addition, the snags would provide benefits to juvenile salmonid fish in the reservoir, which tend to congregate in near-shore areas (Dilley 1994).

Tacoma believes that low-lying vegetation in the inundation zone (1146 feet-1167 feet) may cause taste and odor problems in water to be stored behind HHD for municipal use. This area contains a large amount of vegetation that would decay in the reservoir and potentially contaminate the City's water supply. This may pose a major problem for Tacoma since the City's operation as an unfiltered, surface water supply depends in large part on its ability to provide the public with water that meets rigorous federal and state water quality standards.

Tacoma will undertake an evaluation of the potential contamination of its water supply from the vegetation in the inundation zone, during the pre-construction engineering and design phase of the HHD-AWSP. This evaluation will consist of hiring a consulting firm or individual knowledgeable in the evaluation of public water supply quality concerns to review this HCM in relation to the operation of HHD and the potential for water quality degradation. If deemed necessary, a course of action to protect the quality of the municipal water supply, while minimizing impacts to fish and wildlife habitats, will be coordinated with the Services prior to implementing the action.

Tacoma will assume all financial responsibility for this measure. There is no monitoring plan developed solely for this habitat conservation measure; however, several proposed monitoring activities associated with other measures would determine fish distributions within different sections of the reservoir, and would likely include portions of these areas (see Chapter 6).

5.2.5 Habitat Conservation Measure: HCM 2-05 Juvenile Salmonid Transport and Release

HABITAT CONSERVATION MEASURE NUMBER: HCM 2-05

MEASURE: Juvenile Salmonid Transport and Release

If supplementation of juvenile salmonids into the upper Green River watershed is determined to be beneficial to Green River fish runs by the NMFS and USFWS, Tacoma will transport and release juvenile salmonids above HHD. This measure does not include the production of juvenile salmonids in an incubation and rearing facility, only the transport and release of fish into the upper watershed. This measure complements the transport and release of adult upstream migrating fish at Tacoma's Headworks, and complements the production of juvenile salmonids at the MIT fish restoration facility.

Objective

The objective of this measure is to provide the opportunity to accelerate the re-establishment of anadromous fish production of the Green River above HHD through the transport and release of juvenile fish.

Rationale and Ecosystem Benefits

Tacoma will partially or wholly fund upstream and downstream fish passage facilities to aid in region-wide efforts to restore anadromous fish production to the upper Green River watershed. These facilities will be instrumental to restoring anadromous fish runs above HHD, but other facilities may also be needed to accelerate restoration. Restoring salmon and steelhead runs in the upper watershed could be initiated by transporting and releasing unmarked adult fish above HHD to distribute and spawn naturally in upper watershed, but the rebuilding of harvestable, self-sustaining runs could take many years. A fish restoration facility could be used to "jump-start" or accelerate the natural rebuilding of anadromous fish runs by producing juvenile salmonids for outplanting into the upper watershed to supplement adult returns.

Although not proposed as part of this conservation measure, Tacoma is committed to funding the development and construction of a fisheries restoration facility that will be owned and operated by the MIT. The facility would be constructed adjacent to the Green River, and would be designed to include incubation and rearing facilities for juvenile salmonids patterned after the NMFS natural rearing program (NATURES). These rearing procedures create a more natural environment (e.g., natural cover, substrate, and structures) to incubate, rear, and acclimate fish in order to achieve improved survival and productivity. The juvenile fish produced at the fish restoration facility would be used to restore and enhance anadromous fish populations in the Green River, and could serve as the primary source for juveniles to be outplanted in the upper Green River watershed.

The fish restoration facility would include the following attributes (FishPro 1995):

- weir, ladder, and trap to capture adult anadromous fish;
- adult holding facilities for 300 steelhead trout, 400 chinook salmon, and 440 coho salmon;
- incubation and rearing facilities for 350,000 steelhead trout, 500,000 chinook salmon, and 500,000 coho salmon; and [2]
- well water stabilization facility or surface water treatment for incubation (depending upon source).

Tacoma will pay up to $8,500,000 for design and construction of the fish restoration facility and will provide the necessary wells, well houses, and water conveyance facilities. Tacoma will pay the MIT $350,000 per year (1995 dollars) for operation and maintenance costs for the life of the facility. Tacoma will also fund up to $675,000 for monitoring and evaluation of the fish restoration facility to provide the basis for long-term watershed restoration.

The transport and release of juvenile salmonids is contingent upon a number of factors, including approval of the fish restoration facility and its intended uses (i.e., restoration and supplementation of anadromous fish populations in the Green River) by fisheries resource agencies, and obtaining the necessary water rights and permits for the facility. If the fish restoration facility cannot be permitted or is deemed to be infeasible, the MIT will elect to either:

[2] The capacity of the fish restoration facility may be increased as a result of ongoing discussions between the MIT and Tacoma.

- accept a lump sum of $12,000,000 into MIT's Fisheries Trust Fund to be used for fisheries enhancement within the Green/Duwamish river system; or
- accept any and all unused funds originally targeted for the fish restoration facility into the MIT Fisheries Trust Fund to be used for fisheries enhancement in the Green/Duwamish river system.

Juvenile salmonids produced from the fish restoration facility could be outplanted into the upper watershed until the number of adult fish returning to the upper watershed (via the Headworks trap-and-haul facility) is determined to be sufficient to establish self-sustaining runs. Supplementation on a short-term basis could reduce the period of time required to reach adult escapement goals. In the case of chinook salmon, which are less likely than steelhead to develop self-sustaining runs, supplementation from the fish restoration facility may also be beneficial for addressing short-term declines in adult escapement due to environmental conditions (e.g., temporary population reductions resulting from poor ocean conditions or several years of drought). If limiting aspects of the chinook salmon life cycle cannot be remedied to achieve self-sustaining runs of adult fish (as indicated by the monitoring programs), then long-term supplementation may be required to restore and maintain the production of this species in the upper watershed.

Determining a management plan to recolonize available habitat above HHD is the responsibility of fisheries management agencies. Allowing only adult returns to seed the upper watershed may be an optimal procedure for developing local adaptations, but it would delay habitat saturation. Outplanting juveniles from the fish restoration facility may provide a means of identifying upper watershed outmigrants, or supplementing adult returns may accelerate the rebuilding process. The decision on when, how, or if to use the fish restoration facility will be decided by MIT and appropriate federal and state fish management agencies. The fish restoration facility, and therefore transport of juvenile salmonids into the upper watershed, would only proceed if supplementation of juvenile fish above HHD is found to be beneficial. Even if the fish restoration facility does not proceed, funding of the MIT Fisheries Trust Fund would still provide benefits to fisheries resources within the Green/Duwamish river system.

Tacoma will fund and support the federal, state, and local permitting process for the fish restoration facility, but the MIT, as owners and operators of the facility, will be the permittees if permitting is found to be necessary. If necessary, permits to comply with the Endangered Species Act (ESA) will be issued to the MIT and will be sought as a process separate from the Tacoma Green River HCP. Funding of the fish restoration facility provides for monitoring and evaluation to provide the basis for long-term

watershed restoration, but details will not be developed until the fish restoration facility proceeds.

5.2.6 Habitat Conservation Measure: HCM 2-06 Low Flow Augmentation

HABITAT CONSERVATION MEASURE NUMBER: HCM 2-06

MEASURE: Low Flow Augmentation

The USACE, with Tacoma sponsorship, will have the option to annually provide up to 5,000 ac-ft of additional summer conservation pool storage in Howard Hanson Reservoir that can be used to augment Green River flows. The actual use of this storage will be determined using an adaptive management approach. Although initially intended to augment minimum flows during drought conditions, there is considerable flexibility in determining the best use of the water for fishery resource benefits. For example, the storage may be used to: 1) augment late spring flows to benefit steelhead incubation; 2) provide flows beneficial to downstream water quality conditions (e.g., temperature control); or 3) provide supplemental freshets during late summer to benefit adult salmon migrating up the Green River. The actual use of up to 5,000 ac-ft of storage will consider the input of the resource managers[3] charged with determining the best application of the water to benefit ecosystem health.

Water stored behind HHD and released for fish conservation purposes shall not be subject to appropriation by Tacoma.

Objective

The objective of this measure is to provide additional water in the Green River during low flow periods that can be used for optimal benefit of fish

Rationale and Ecosystem Benefits

Under drought conditions, low summer flows in the mainstem Green River can reduce the availability and quality of salmonid rearing habitat. In Puget Sound streams, Gibbons et al. (1985) suggested that the amount of available summer rearing habitat, which is established by the level of instream flow, is directly related to the number of returning adult steelhead. Other researchers confirm this relationship stating "the volume of flow in summer determines the carrying capacity of the stream for juvenile salmonids" (Everest et al. 1985). Research over a 14-year period in Bingham Creek, Washington

[3] See footnote No. 3 in HCM 2-02 for description of the Green River Flow Management Committee.

showed that the quantity of water during summer accounted for over 95 percent of the inter-annual variation in smolt production (Parkhurst 1994). Similarly, extensive research has indicated that production of coho salmon in Oregon streams was found to be most strongly correlated with the amount of useable rearing habitat rather than other parameters (Mason and Chapman 1965; Everest et al. 1985).

During non-drought years, incubating steelhead eggs are exposed to a risk of dewatering if river flows drop during June through August. The majority of steelhead in the Green River spawn during the months of April and May, and the eggs incubate for 45 to 65 days extending through July or early August (see Appendix A). If steelhead construct their nests (redds) in the channel margins during April and May when flows in the river are high, the eggs are susceptible to dewatering as the seasonal flows drop during the incubation period. During dry years, river flows are often low during the spawning season and the eggs will remain protected from dewatering by Tacoma's commitment to maintain minimum flows. However, during wet years, the steelhead spawn higher in the channel margins and as flows naturally drop during June and July, the eggs may be dewatered and have poor survival. During wet years, additional protection for steelhead redds may be provided by maintenance of instream flows that are higher than those mandated by the state or by the MIT/TPU Settlement Agreement.

Tacoma is considering implementing this measure through the USACE's Section 1135 Program or as part of the AWS project. The capture and retention of up to an additional 5,000 ac-ft of water will provide supplemental flows that can be used to augment low summer flows during drought conditions, or augment flows during June and July to protect steelhead incubation, or released during late September to aid the upstream migration of adult salmonids. All of these potential uses of an additional 5,000 ac-ft of storage will benefit Green River fishery resources. The actual use of the additional flow will by determined by the NMFS and USFWS in coordination with the USACE and other resource managers.

5.2.7 Habitat Conservation Measure: HCM 2-07 Side Channel Reconnection – Signani Slough

HABITAT CONSERVATION MEASURE NUMBER: HCM 2-07

MEASURE: Side Channel Reconnection – Signani Slough

Tacoma and the USACE will restore and enhance up to 3.4 acres of side channel fish habitat in Signani Slough near RM 60.0. This will be accomplished through: 1) excavation of fill material; 2) replacement of a 48-inch culvert; 3) addition of LWD and

excavation in the floodplain to restore habitat complexity; and 4) diversion of up to 35 cfs flow from the mainstem Green River to provide additional water for the entire channel length. All work will be performed within the historic Green River floodplain. The Headworks road will be breached at two points to provide flow diversion at the upstream end by installing a 2- to-4-foot culvert, and replacing an existing 4-foot HCM culvert (downstream end) with either one or two longer culverts. Flow diversion to the upstream end will require starting 600-1,000 feet upstream of the breach near RM 59.6. The outlet channel may require re-alignment and may extend farther downstream than the current channel. This habitat conservation measure is intended to restore habitats that were impacted by the construction of HHD.

Alternate measures will be implemented if the above measure is determined to be infeasible, or not cost-effective during final design, or if environmentally superior measures can be implemented at comparable cost. Any alternate measures will have habitat benefits greater than or equal to the measure originally proposed, and will be reviewed and approved in advance by the NMFS and USFWS.

Objective

The objective of this measure is to provide additional rearing and holding habitat for salmon and steelhead along the Green River.

Rationale and Ecosystem Benefits

Levees, channel degradation, and controlled flows from HHD have reduced the interaction between floodplains and stream channels in many sections of the Green River (Fuerstenberg et al. 1996). Many areas of the floodplain have been converted to other uses, dramatically reducing the interchange of water and materials between the aquatic and terrestrial systems, and isolating floodplain wetlands. The lower 1,000 feet of Signani Slough, a left bank Green River side channel, was filled, channelized, and disconnected during original construction of HHD and re-alignment of the Burlington Northern Santa Fe Railroad in 1960 and 1961. During construction activities, the channel was filled and temporarily cut off from the Green River, reportedly stranding over 1,000 adult salmon (Signani 1997).

In general, side-channels have been shown to provide important habitat for juvenile and smoltified salmon and steelhead (Sedell et al. 1984; Murphy et al. 1989; Marshall and Britton 1990; Sheng et al. 1990; Bonnell 1991; Cowan 1991). The restoration of Signani Slough would add to the overall quantity and quality of fish habitat in the upper middle Green River, in particular for: 1) adult coho salmon and steelhead, and 2) juvenile chinook, coho salmon, and steelhead. The Signani Slough is the only available off-

channel spawning and rearing habitat of any significance for the middle Green River, from RM 45.0 to RM 70.0. Being partially fed by groundwater, this slough may represent a critical Green River habitat type. The re-connection of Signani Slough would provide approximately 3.4 acres of critical rearing habitat for juvenile salmonids, and may provide spawning habitat for adult salmon and steelhead and nursery areas and feeding stations for newly emerged fry.

5.2.8 Habitat Conservation Measure: HCM 2-08 Downstream Woody Debris Management Program

HABITAT CONSERVATION MEASURE NUMBER: HCM 2-08

MEASURE: Downstream Woody Debris Management Program

Tacoma, working collaboratively with the USACE, MIT, and federal, state, and local agencies will develop and implement a woody debris management program designed to pass wood that collects behind HHD downstream to the middle and lower Green River (below Tacoma Headworks). As part of their HHD maintenance operations, the USACE collects woody debris that enters the HHD reservoir and disposes of the wood by burning or transporting it off-site. For this measure, all of the Large Woody Debris (LWD) and a portion of the small woody debris that enters the HHD reservoir and is collected by the USACE as part of debris removal operations will be used for ecosystem rehabilitation efforts. The actual volume of wood that will be available for rehabilitation efforts will vary, depending on source material available within the HHD reservoir pool. The wood debris management program may be modified by agreement of signatories to the Incidental Take Permit.

Large Woody Debris (LWD)

Following construction of the AWS project, Tacoma, working with the USACE, will allocate [4] for passage downstream of Tacoma's Headworks at least half of the LWD that is collected by the USACE behind HHD. **The size distribution of wood passed or placed below the Headworks shall be approximately the same as that wood entering the reservoir, and will include the largest sizes available. If monitoring indicates that the large wood is too small to be naturally retained, then the proportion of the largest size class will be increased.** ~~Wood allocated for transport downstream of Tacoma's Headworks will be representative of the size, species, and~~

[4] **Large Woody Debris pieces will be considered allocated if one of the following conditions are met: 1) a permit has been submitted for a project: 2) a project design is being developed; or 3) an entity has made a request for the wood for use in a project in the Green River basin. Large woody debris pieces that remain unused because of the lodging or filling of an appeal or litigation in any forum that has the potential to interfere with the placement of wood under this section shall be considered allocated.**

~~age of wood collected by the USACE behind HHD.~~ If more than ten pieces of LWD are available in any given year, 50 percent of the total number of pieces collected will be allocated for downstream passage. If less than 10 pieces of LWD are available in any given year, all LWD pieces will be allocated to downstream passage. If an unusually large volume of wood is collected in any given year, such as contributions from a major landslide, Tacoma reserves the option to reduce the amount of LWD collected, stored, and transported contingent on written approval by the Services. The approximate size criteria of the LWD that will be used are as follows: logs will have an average diameter of at least 12 inches at the largest end or bole above the rootwad if attached and will be at least 12 feet long; rootwads will have a minimum diameter of 48 inches with or without the basal trunk.

Large woody debris collected by the USACE will be temporarily stored for up to three years. At an average frequency of every other year, the LWD allocated for passage downstream will be re-loaded and trucked below the Headworks on existing roads. It is anticipated that LWD will be introduced at several locations within the active channel of the Green River prior to winter high flows. The LWD will then be allowed to distribute naturally within the river as flow and the natural transport capacity increase.

In addition to, or as an alternative to placing unanchored LWD downstream of the Headworks, select pieces of LWD may be anchored in the river, rather than allowing flows to distribute the pieces naturally. In this case, the locations and methods for anchoring LWD are downstream of the Headworks will be determined in coordination with MIT, and federal, state and local agencies with jurisdiction over habitat protection and river management. If LWD is anchored, fewer pieces may be added to the river to ensure implementation costs remain comparable to those for placing unanchored LWD.

Following construction of the AWS project, any LWD collected from the reservoir and not allocated for downstream transport below the Tacoma Headworks will be stored and used for other conservation measures identified in this HCP. Once the LWD requirements for those conservation measures have been fulfilled, any remaining LWD will be allocated for use in other USACE sponsored rehabilitation projects in the Green River basin or offered to tribal; federal, state, or local agencies; or non-profit organizations for use in habitat rehabilitation projects elsewhere in the Green River basin. If sufficient pieces of LWD are available to meet short-term needs for ecosystem rehabilitation projects, select pieces of LWD will be made available for cultural use by the Muckleshoot Indian Tribe. If the LWD remains **unallocated** ~~nutilized~~ following three years of storage, and provided inter-basin contamination issues **can be** adequately addressed, **and provided that the LWD pieces in storage are decaying to an extent that if not used, the LWD pieces will become unusable for ecosystem rehabilitation or habitat projects unallocated** ~~unutilized~~ LWD pieces will be made available for ecosystem rehabilitation projects outside of the Green River basin. If any LWD remains unutilized after five years of storage, Tacoma will use best available efforts to utilize remaining LWD for regional ecosystem rehabilitation efforts.

Small Woody Debris

In addition to the LWD, five trash-truck loads (total 50-75 tons) of small woody debris (if available) will be transported to placement sites downstream of the Tacoma Headworks at an average placement frequency of every other year. The actual volume of small woody debris that will be collected, transported, and introduced into the lower river will vary, depending on source material available within the HHD reservoir pool. Small woody debris will consist of small logs, branches, and other wood fragments with an average diameter of less than 12 inches. **If five trash-truck loads are not available, then Tacoma will transport the available quantity.**

Funding

In addition to costs allocated for the storage and transport of wood for unanchored placement downstream of Tacoma Headworks, a sum of $5,000 will be annually allocated for anchored LWD placement. If not used in any given year, these funds will be carried over to subsequent years to build up a funding bank for future LWD anchoring projects. The volume of woody debris transported downstream can be adjusted predicated on an evaluation of the volume of wood that will effectively contribute to natural stream processes, public health and safety, and flood control impacts. Monitoring activities associated with this measure are described in Chapter 6.

Tacoma will work with the MIT, federal, state, and local agencies with jurisdiction to select wood placement locations. If recommendations for LWD placement require alternate placement procedures such as anchoring, the quantity of LWD placed may be reduced to ensure costs remain comparable. If problematic LWD accumulations in the middle or lower river are identified (as determined by the NMFS and USFWS), the rate of placement may be reduced and funds reallocated to other habitat restoration measures. If monitoring indicates that an increased rate of LWD placement would be beneficial, funds for additional wood transport and placement must come from other sources.

Objective

The objective of this measure is to increase the amount of LWD in the Green River below the Tacoma Headworks Dam, where it has been reduced by timber harvest, construction of HHD, and active removal from the river.

Rationale and Ecosystem Benefits

Woody debris are perhaps the most important link between the aquatic and terrestrial environments. Woody debris interacts with other natural processes (i.e., climate, hydrology, and erosion) to create food, cover, and microclimates suitable for virtually all species of juvenile salmonids at some point during their maturation (Chapman 1966; Murphy et al. 1984; Bjornn and Reiser 1991; Swanston 1991). In the Pacific Northwest,

current breaks providing velocity shelter, summer/winter rearing habitat for juvenile salmonids, and spawning gravels for adult salmonids often form in the presence of woody debris (Sedell et al. 1984; Dolloff 1987; Shirvell 1990; Fransen et al. 1993; Peters et al. 1993; Rodgers et al. 1993; Hartman et al. 1996; Fausch and Northcote 1992; Crispin et al. 1993; Cederholm et al. 1997a). The deposition of key woody debris pieces also initiates pool formation (Beechie and Sibley 1997); prompts bar, island, and side channel formation (Sedell et al. 1984; Abbe and Montgomery 1996); stores sediment (Lisle 1986; Keller et al. 1995); retains organic matter (Bilby and Likens 1980); and affects bedload transport mechanics (Smith et al. 1993).

Woody debris also exerts a significant influence on the productivity of Pacific Northwest streams. Woody debris are important in retaining organic matter in fluvial systems that will later be processed by aquatic macroinvertebrates and converted to fish production (Bilby and Likens 1980). Key woody debris pieces traps smaller woody pieces, until a framework is built. Coarse particulate matter collects on the framework and is refined by bacteria and fungi into food for macroinvertebrates. Macroinvertebrates, in turn, are an important food source for salmonid fishes.

Lateral habitats containing large woody debris are regularly associated with high juvenile salmonid production rates. Peterson and Reid (1984) found that 15 of 17 (88 percent) wall base channels in the Clearwater River, Washington were used by juvenile coho and estimated that, annually, 20 to 25 percent of the total smolt yield in the Clearwater River comes from wallbase channel habitat. Some groundwater-fed side channels in British Columbia produce more than one coho smolt per square foot of habitat area (Sheng et al. 1990), by comparison, coastal British Columbia streams produce approximately 0.3 smolts per square foot (Marshall and Britton 1990). Approximately 16,000 juvenile coho salmon overwintered in a side channel in the upper Squamish River, British Columbia (Sheng et al. 1990). Juvenile chum salmon also utilize side channel areas for rearing habitat (Sheng et al. 1990; Bonnell 1991; Cowan 1991), however their freshwater residency is usually limited to 30 days or less (Salo 1991). The density of juvenile chinook using off channel habitat in the Taku River, Alaska increased in November, indicating movement into overwinter habitat (Murphy et al. 1989). Everest and Chapman (1972) found post-emergent chinook in Idaho seek backwater habitats, almost exclusively, during spring freshets. Chinook fry are also known to use quiet, shallow waters soon after emergence in the Green River (Jeanes and Hilgert 1999). Off channel rearing has also been documented for rainbow trout (Everest et al. 1987; Sheng et al. 1990; Hartman et al. 1996), bull trout (Goetz 1994), and cutthroat trout (Sedell et al. 1984; Hartman et al. 1996).

Woody debris is recruited to the stream system in a number of ways. On large, unconfined rivers, lateral migration of the stream channel undercut banks, delivering whole trees with attached rootwads to the channel (Robison and Beschta 1990). Other sources of woody debris recruitment include landslides, windthrow, and floods. Most (83 percent) of the hardwood woody debris pieces originate within 33 feet of the stream margin as compared to only 53 percent of coniferous woody debris pieces (McDade et al. 1990). This discrepancy is often attributed to the size differences between the two woody debris types.

Once in the stream, most pieces smaller than the bankfull width of the channel are transported considerable distances downstream. The narrow straight reaches of a river are generally considered source reaches, while lower gradient valley floors serve as woody debris traps (Murphy and Koski 1989). In large rivers, the number of woody debris jams are fewer, but individual pieces and jams are usually larger, and often cause secondary channels to form (Sedell et al. 1984). Recently recruited woody debris usually comprises the majority of wood in Pacific Northwest streams (Hyatt 1998). For example, most of the woody debris in the Queets River was depleted within the first five decades of its deposition; however, a few pieces were over 1,000 years old (Hyatt 1998). Older pieces are often found exposed in gravel bars, where they may remain buried beneath alluvial deposits in anaerobic conditions for many years before being exhumed by high flow events. In contrast, recently recruited debris is often found entangled in debris jams.

The deterioration of freshwater habitat is listed as a contributor in the decline of may anadromous fish species, and in many cases that deterioration is linked to loss of large woody debris (Nehlsen et al. 1991; Weitkamp 1995; Myers et al. 1998). Most alluvial rivers in the Pacific Northwest formerly contained extensive debris jams. Historically, the Skagit River had a debris jam that measured almost 0.75 miles in length and over 1,300 feet wide (Sedell and Luchessa 1982). The Nooksack and Stillaguamish rivers were also choked with debris jams over their lower reaches (Sedell and Luchessa 1982). In 1906, a large logjam on the Puyallup River between Orilla and Kent, Washington, caused major flooding on both the Green and White rivers (Fuerstenberg et al. 1996).

Historically, the middle Green River probably supported much higher frequencies of debris jams. However, the source of woody debris has been reduced drastically through a series of dikes, conversion of forested floodplains to agricultural land uses, and the addition of Howard Hanson Dam. Howard Hanson Dam was constructed at the confluence of the three largest tributaries in the upper Green River basin. Prior to

creation of the reservoir, these tributaries carried large volumes of LWD downstream to lower reaches of the Green River. Since creation and operation of the dam and reservoir, normal river transport of wood has been disrupted, as all pieces of wood are either collected and disposed of (via burning or transport and use off-site), or are stranded at higher elevations following a flood pool rise. As recent as 1994, a survey indicated that only 29.6 pieces of woody debris were available per stream mile in the middle Green River downstream of Howard Hanson Dam (Fuerstenberg et al. 1996).

Under current conditions, woody debris in the middle Green River (Flaming Geyser State Park downstream to Auburn, Washington) is often closely associated with lateral areas of the mainstem and off-channel habitats (e.g., side channels, sloughs, gravel bar pools, and beaver ponds). In many instances, debris accumulations divert water into side channels. At RM 45.5, the Green River exits the gorge area near Flaming Geyser State Park and enters a broad valley, characterized by a decrease in gradient and deposition of gravel (Perkins 1993). This broad river valley provides the perfect conditions for the accumulation of woody debris and formation of lateral or side channel habitat (Sedell et al. 1984; Hyatt 1998).

Many habitat rehabilitation projects occurring in the Pacific Northwest include the placement of woody debris in streams (Cederholm et al. 1997b). Among the most common structures used in larger rivers include: log deflectors facing downstream, channel margin log-boulder accumulations, angle logs, boulder-rootwad complexes, trees anchored to the streambank, trees with attached stem cabled to boulders, boulder-wood debris complexes, divide logs situated within boulder weirs. The physical and biological design specifications along with a thorough understanding of the geomorphic processes are imperative to maximize the benefits of projects of this nature (Cederholm et al. 1997b).

This conservation measure provides a means for restoring recruitment of LWD from the upper to middle and lower reaches of the Green River. In addition to providing in-channel rearing habitat for juvenile salmonids (Fuerstenberg et al. 1996), the release of LWD should interact with the restoration of the Signani Slough and other habitat rehabilitation projects to improve the overall quality of instream habitat in the Green River below the Headworks. By guaranteeing that at least half of the wood delivered to Howard Hanson Reservoir is passed downstream of the Headworks and either allowed to distribute freely or placed in the channel using techniques such as those described above, Tacoma expects to substantially increase the amount of functional LWD in the Middle Green River.

Large woody debris delivered to the reservoir is collected in log booms that are approximately 1 acre in size. Approximately 2 to 7 acres (about 100 to 150 tons) of wood are collected annually (Olson 1999). The actual amount collected varies widely since LWD input and transport are episodic in nature, and tends to be highest in years with major flood events. If more than ten pieces are collected in any year, fifty percent of the pieces collected will be made available for other habitat restoration projects. If allowed to freely distribute, LWD allocated for downstream passage will be input at least every second year. If it is determined that anchoring individual pieces or groups of LWD is the preferred means of restoring LWD to the river, the wood may be stored for up to five years and then input all at once, to maximize construction efficiency and cost effectiveness.

Large and small woody debris placed in the river from subsequent distribution by high flows will be input on exposed gravel bars within the active channel during low flows. Specific locations chosen for in-channel LWD placement will be identified in coordination with the Services, USACE, MIT, and King County. Placement locations must be accessible to trucks and heavy equipment and must not require crossing of wetted channels or unstable banks. The number of placement locations will vary depending on the amount of wood to be placed in any given year.

LWD must be greater than 9 m^3 by volume (24 inches in diameter and over 100 feet long) to be considered a stable, key piece in such channels (NWIFC 1997). The Green River is a wide, high energy stream channel. Hardwood species (alder or cottonwood) generally decay more rapidly and are less durable than conifers. Therefore only LWD from coniferous species including fir, hemlock, cedar, or spruce will be used for anchoring projects in the mainstem Green River. In addition, LWD anchored in the channel will have a volume of least 11 yd^3, or will be installed in groups that have a collective volume of 11 yd^3, which is consistent with the minimum key piece size for larger rivers (WFPB 1997). The total volume may consist of a single piece with an average diameter of 24 inches that is at least 105 feet long, shorter pieces with larger diameters (NWIFC 1997), or a group of smaller pieces with a collective volume of at least 11 yd^3. Other design criteria (orientation, anchoring method) will be determined in coordination with the Services on a site specific basis.

5.2.9 Habitat Conservation Measure: HCM 2-09 Mainstem Gravel Nourishment

HABITAT CONSERVATION MEASURE NUMBER: HCM 2-09

MEASURE: Mainstem Gravel Nourishment

Tacoma and the USACE will provide annual funding sufficient to place up to 3,900 yd^3 of screened gravel suitable for use by spawning salmonids within the mainstem Green River between RM 64.5 and RM 32.8. **The amount of screened gravel to be placed each year will be approximately 3,900 cubic yards, but not exceed 3,900 yards. The amount of gravel to be placed will be reduced only: 1) at the specific request of the Services; or 2) if the preferred placement strategy calls for placement of a lesser amount of gravel in conjunction with construction of structures deliberately designed and placed to retain gravel; independent of the placement of wood under HCM 2-08.** Preliminary analyses indicate that the middle Green River just below the Green River Gorge near RM 45.0 is the preferred placement site (USACE 1998). Should Green River restoration efforts by other parties place gravel in the RM 45.0 area, the USACE/Tacoma gravel nourishment site will be switched to an area immediately below Tacoma's Headworks at RM 61.0 If deemed beneficial by the Services, gravel may be placed between HHD (RM 64.5) and Tacoma's Headworks. Gravel will be transported by truck and placed (with front-end loader or back-hoe) just within the active channel to be subsequently transported and distributed during high flow conditions. Actual sites for placement of the gravel will be selected based on river access. This program is focused on augmenting the supply of gravel within the middle Green River.

Should high flows be insufficient to redistribute all of the gravel placed in a given year, subsequent annual placements may be shifted to the reach between the Headworks and the Green River gorge or between HHD and Tacoma Headworks, conditional upon approval by the Services. One alternative would be to place the entire annual increment just downstream of the Headworks as described above. Another option would be to install **gravel retention structures** ~~boulder weirs~~ at selected locations to facilitate gravel storage in this high energy reach. Actual placement strategies will be modified based on the results of monitoring.

Tacoma will work with the MIT, federal, state, and local agencies with jurisdiction to select gravel placement locations. If recommendations for gravel nourishment require alternate placement procedures, the quantity of gravel may be reduced to ensure costs remain comparable. If problematic gravel aggradation in the lower river is identified (as determined by the NMFS and USFWS), the rate of placement may be reduced and funds reallocated to other habitat restoration measures. If monitoring indicates that an increased rate of gravel nourishment would be beneficial, funds for additional gravel must come from other sources. Changes in the volume or location of placement sites will require approval by the Services and written notification to WDFW, MIT, King County, and the USACE.

Objective

The objective of this measure is to increase the amount of spawning gravel in the mainstem Green River below the Tacoma Headworks Dam, where it has been reduced by construction of HHD.

Rationale and Ecosystem Benefits

Studies have shown that the existing supply of gravel within the mainstem river is being influenced by the operation of HHD, resulting in changes in channel morphology and in bed armoring (Perkins 1993; Dunne and Dietrich 1978). In addition, HHD essentially captures all gravel that may be recruited from the upper watershed, thereby precluding the natural replenishment of spawning gravel to segments of the river below the dam. Over time, this will ultimately result in the gradual degradation of suitable spawning habitats in the mainstem river, thereby reducing the anadromous fish production potential. Other concerns relate to the perching (disconnection) of off-channel habitats from the mainstem as channel downcutting occurs and the bed becomes armored. King County researchers have documented a loss of suitable-sized spawning gravel with resultant bed armoring from below HHD (RM 64.5) to below Flaming Geyser State Park (~RM 45.0) (Perkins 1993). This armoring layer is estimated to be advancing downstream at the rate of 700 to 900 feet per year.

As noted in the AWS project DFR/DEIS, Appendix F1, Section 4B: gravel nourishment in the middle and upper Green River (USACE 1998), the 3,900 cubic yards of gravel to be distributed to one or more sites in the river, is intended to maintain "an increment" of existing spawning habitat in the middle Green River. The objective of gravel nourishment is to slow or stop the downstream extension of streambed armoring and to replenish certain areas currently deficient in spawning-sized sediments. Preliminary analysis suggests that gravel of a size suitable for use by spawning salmonids would have a short residence time in the channel upstream of Kanasket State Park (USACE 1998), therefore, the reach immediately downstream of the gorge was identified as the preferred placement site. The extent to which gravel nourishment successfully stops continued streambed armoring would be identified through monitoring and evaluation. A major concern, voiced by the USACE, of adding gravel-sized sediments to the middle Green River, is the potential effect on flood control measures in the lower river. As described in Chapter 6, a monitoring plan is proposed to minimize the risk of problematic aggradation downstream of gravel placement sites.

The ecosystem restoration aspects of the AWS project are capped by financial constraints under federal authorization Section 216. If problematic gravel aggradation in the lower

river is identified, the rate of gravel nourishment may be reduced. If monitoring identifies the value of an increased rate of gravel nourishment, funds for additional gravel must come from other sources. The responsibilities of the USACE for the effects of HHD operations under the ESA have not yet been identified **through formal Section 7 consultation, and additional gravel nourishment may be a Section 7 requirement**. The Green/Duwamish River Basin Ecosystem Restoration Study sponsored by the USACE and King County is **also considering placement of gravel in the Green River.** ~~a possible source for additional funding.~~

5.2.10 Habitat Conservation Measure: HCM 2-10 Headwater Stream Rehabilitation

HABITAT CONSERVATION MEASURE NUMBER: HCM 2-10

MEASURE: Headwater Stream Rehabilitation

Tacoma will contribute funds to rehabilitate a portion of the habitat lost by construction of Howard Hanson Dam and inundation of the existing pool. Project numbers assigned to each activity by the USACE are listed in parentheses. Projects **currently expected** to be funded by Tacoma **as part of the AWS project** under HCM 2-10 include:

Mainstem and Valley Floor Habitat Rehabilitation (MS-03). This project will rehabilitate habitat in approximately 8,000 feet of channel between RM 69 and RM 72 (elevation 1,177-1240 feet MSL), just upstream of the new inundation zone. Boulders will be placed along the thalweg, and LWD will be embedded in the banks or anchored to placed boulders. Relict side channels or beaded ponds will be excavated within the floodplain to increase the quantity of off-channel habitat, and LWD will be placed to improve the quality of newly excavated habitat features.

Tributary Habitat Rehabilitation (TR06; TR07). These projects will rehabilitate habitat between 1,177 feet MSL and 1,240 feet MSL in the North Fork Green River, Charley, Gale, McDonald, Cottonwood, Piling and three unnamed tributaries. Large woody debris and boulders will be placed in approximately 14,000 feet of channel. Relict side channels or beaded ponds will be excavated within the floodplain of larger tributaries to increase the quantity of off-channel habitat, and LWD will be placed to improve the quality of newly excavated habitat features.

The final design of these conservation measures will be developed during the pre-construction engineering and design phase of the AWS project. Large woody debris frequency and size requirements appropriate for the channel type will be determined using habitat criteria such as those recommended by the Washington Watershed Analysis Manual (WFPB 1997) or comparable systems approved by the Services.

Alternate measures will be implemented if any of the above measures are determined to be infeasible or not cost-effective**, or if environmentally superior measures can**

be implemented at a comparable cost ~~during the final design~~. Any alternate measures will have habitat benefits greater than or equal to the measure originally proposed, and will be reviewed and approved in advance by NMFS and USFWS.

Objective

The objective of this measure will be to rehabilitate and/or enhance fisheries habitat in the Green River and selected tributaries above HHD.

Rationale and Ecosystem Benefits

The construction of HHD resulted in the inundation of several miles of mainstem and tributary habitat. The primary objective of projects identified in this measure is to mitigate for a portion of that lost riverine habitat by rehabilitating habitat in several important tributary streams in the upper watershed. Surveys of the mainstem Green River, North Fork Green River, Charley and Gale creeks in 1991 reported that LWD frequencies ranged from 1.2 to 47.6 pieces of LWD per 1000 feet (USFWS 1992). This generally corresponds with the low end of the range of LWD frequencies (9 to 140 pieces/1,000 feet) reported by Peterson et al. (1992) for comparable large streams (>75 feet BFW) flowing through undisturbed forests. LWD frequencies in the smaller tributaries (Cottonwood and Piling creeks, and three unnamed tributaries) were higher, ranging from 26.9 to 179 pieces per 1,000 feet (USFWS 1992). However, the LWD frequency in those smaller tributaries is generally much lower than the 122 to 244 pieces per 1,000 feet reported for comparable medium size streams (15 to 32 feet BFW) flowing through undisturbed forests (Peterson et al. 1992). The riparian prescriptions to be implemented under this HCP are expected to eventually provide higher levels of LWD recruitment once stream adjacent stands of timber mature. This conservation measure will provide immediate benefits in the form of increased instream structure, and is expected to improve juvenile salmonid rearing habitat and potentially increase spawning habitat for adult steelhead or salmon.

The existing LWD frequency is currently less than the 2 pieces per channel width recommended for channels with "good" habitat conditions (WFPB 1997) in the majority of channels surveyed. Placement of LWD at an average rate of 40 pieces per 1,000 feet is expected to increase the LWD frequency to more than 2 pieces per channel width in all of the treated segments. Addition of large boulders at a rate of 30 boulders per 1,000 linear feet will further increase channel complexity, and will provide stable obstructions to help retain both naturally recruited and placed LWD. Construction of beaded ponds and side channels increase the availability of off channel habitats that are utilized for spawning and rearing by most salmonid species. The addition of LWD and creation of

off-channel habitat just upstream of the inundation zone is expected to increase the amount of available instream juvenile rearing habitat, and to potentially increase spawning habitat for adult steelhead or salmon released above HHD.

The final design of these projects will be developed during the pre-construction engineering and design phase of the AWS project. Alternate measures will be implemented if any of the above projects are determined to be infeasible or not cost-effective during the final design. Any alternate projects will have habitat benefits greater than or equal to the measure originally proposed, and will be reviewed and approved in advance by NMFS and USFWS.

5.2.11 Habitat Conservation Measure: HCM 2-11 Snowpack and Precipitation Monitoring

HABITAT CONSERVATION MEASURE NUMBER: HCM 2-11

MEASURE: Snowpack and Precipitation Monitoring

Tacoma will provide funding to assist the USACE with the installation of three snowpack and precipitation monitoring stations in the upper Green River basin. Unless superior technology becomes available at a comparable cost, snowpack and precipitation monitoring stations will consist of the standard equipment installed by the Natural Resource Conservation Service at their Snowpack Telemetry (SNOTEL) stations. Continuous snowpack monitoring will be accomplished by installing snow pillows within 1,000-foot elevation bands (2,500 to 3,500 feet MSL; 3,500-4,500 feet MSL; and 4,500 to 5,500 feet MSL). Snow pillows are fluid-filled pillows in which fluid pressure responds to the weight of snow that is lying on top of the pillow. The pressure of the fluid in the pillow is measured with a manometer or pressure transducer that is interfaced with a digital data recording and transmission system. In addition to monitoring the snowpack, each site will also be equipped with a rain gage and instruments that measure air temperature and snow depth. Data will be collected from the snow pillows on an hourly basis by the Natural Resource Conservation Service, and provided to the USACE for incorporation into their streamflow forecasting procedures. The snow pillows will be monitored using a continuous data recorder, and data will be transmitted to the Natural Resource Conservation Service Centralized Forecasting System using meteorburst telemetry. Manual snow surveys will be conducted at each new SNOTEL site for the first two years of operation to verify the reliability of telemetered data. The number of snowpack and precipitation monitoring stations may be reduced if the Natural Resource Conservation Service determines that additional sites do not improve the ability of the USACE to forecast spring and summer flows in the mainstem Green River. Less than three SNOTEL stations may also be installed if technology becomes available that will provide a comparable level of run-off forecasting with fewer than three additional sites.

Alternate measures will be implemented if any of the above measures are determined to be infeasible, or not cost-effective during final design, or if superior measures can be implemented at comparable cost. Any alternate measures will have benefits greater than or equal to the measure originally proposed, and will be reviewed and approved in advance by the NMFS and USFWS.

Objective

The objective of this measure is to improve the ability of the USACE to predict stream flows in the Green River.

Rationale and Ecosystem Benefits

Precipitation that falls as snow is temporarily stored in the snowpack during the winter, thus estimates of runoff can be made well in advance of its occurrence. Forecasts of runoff are based primarily on measurements of precipitation, snow water equivalent, and seasonal runoff to date. Water supply forecasting for the Green River basin is currently the responsibility of the USACE, and is used to guide flood control operations, reservoir refill, and the summer flow release schedule. The USACE currently relies on a combination of data obtained from: 1) six snow courses within the Green River basin that are surveyed monthly between January and May; 2) daily telemetry data (obtained between 1 November and 1 July) from five existing SNOTEL sites, only one of which is located within the Green River basin; and 3) temperature and precipitation data from Howard Hanson Dam. The USACE have developed regression equations for 1 March, 1 April, and 1 May to predict spring runoff based on the amount of snow on the ground and year-to-date rainfall. Forecasts produced using the existing models and data network are accurate to within 25,000 ac-ft over the period of April through July.

Runoff forecasts become more accurate as more of the parameters affecting runoff are measured directly within the basin of interest. Rain and snowfall may vary widely with elevation, snow depth, snow water equivalent, snowpack condition, and melt rates are influenced by elevation, aspect and vegetation cover. Additional snow pillows installed at higher and lower elevations within the upper Green River basin will provide data that are more representative of conditions throughout the basin than SNOTEL sites outside of the basin. The availability of additional data on actual basin snowpack conditions, and daily and hourly precipitation and air temperatures throughout the flood season will enhance the ability to predict and respond to flood events during the fall and winter (Murphy 1999). The availability of local, near real-time snowpack data has been shown to improve correlations between actual and predicted runoff from 0.45 to 0.90 (Moore 1998).

The availability of continuous data from the upper Green River basin will also facilitate more frequent spring runoff forecasts, and increase the accuracy of long-term spring runoff predictions. Currently, April through July runoff forecasts based on data derived from the snow course surveys and rainfall are made on 1 March, 1 April, and 1 May. SNOTEL sites within the Green River basin would make mid-month spring runoff forecasts possible. Mid-month spring runoff forecasts would be particularly helpful during years when an early start to refill is necessary (Murphy 1999). More accurate predictions will allow the Green River Flow Management Committee more flexibility in designing a spring refill and summer release program that minimizes impacts to downstream resources while meeting water storage requirements for municipal use and summer instream flow augmentation.

SNOTEL sites funded by other resource management agencies or data users are installed and maintained by Natural Resource Conservation Service personnel. The Natural Resource Conservation Service recommends, and may assist with, manual snow surveys at the snow pillow site during the first two years following installation (Pattee 1999). Manual monthly surveys are used to evaluate the reliability of the telemetered data and identify any site characteristics (e.g., overhanging trees, drainage, deposition patterns on the pillow surface) that may need to be adjusted. Annual maintenance visits will be conducted by Natural Resource Conservation Service personnel during the summer to drain the precipitation gage, replace the antifreeze solution and conduct an electronic analysis of the data logger and other system components.

Snow pillows are currently the most common means of collecting continuous snowpack data from remote measurement sites. However, snow pillow data may be off by 10 percent or more due to bridging of compact snow around the edges of the pillow (Gibbs 1999). Improved technologies are under development (Gibbs 1999). If more accurate snowpack or precipitation monitoring devices become available at a comparable cost, Tacoma may modify the proposed snowpack and precipitation monitoring system, in coordination with the USACE and Natural Resource Conservation Service. If alternative technologies are utilized, Tacoma will notify the Services and provide a description of the alternative systems prior to their installation.

5.3 Habitat Conservation Measures – Type 3

Habitat conservation measures defined as Type 3 are designed to offset Tacoma activities not associated with the operation of Tacoma's water supply system on the Green River, but that have been proposed as a mitigation activity within the HCP area (Green River floodplain).

5.3.1 Habitat Conservation Measure: HCM 3-01 Upland Forest Management Measures

UPLAND FOREST MANAGEMENT MEASURES

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-01A

MEASURE: Forest Management Zones

Tacoma will manage lands within the HCP Area above the Headworks (Upper HCP Area) according to one of three designations: Natural Zone, Conservation Zone, and Commercial Zone. Zone designations for existing lands in the Upper HCP Area will be as shown in Figure 5-4. Zone designations for lands added to the Upper HCP Area in the future will be made by Tacoma, in coordination with the WDFW, USFWS, and NMFS. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to designate management zones in the upper Green River watershed that are consistent with maintenance of water quality and protection of fish and wildlife habitat.

Rationale and Ecosystem Benefits

Tacoma owns and manages approximately 14,888 acres in the upper Green River watershed. These lands are managed to: 1) protect water quality; 2) provide habitat for fish and wildlife; and 3) generate revenues through the limited harvest of timber to fund the overall land management program and finance the acquisition of additional lands in the watershed (Ryan 1996). The protection of water quality is the primary management objective throughout the watershed, but varying amounts of active management can occur to meet the other two objectives without compromising water quality. The amount of management that can occur in a given area without negatively impacting water quality is largely a function of proximity to surface water, particularly to the mainstem Green River and its major tributaries. To account for these site-specific differences in the level of concern for water quality, the ownership has been divided into three management zones (Natural, Conservation, and Commercial) and management measures have been developed specific to each zone. Those management measures with relevance to fish and wildlife habitat have been incorporated into this HCP. As additional lands are acquired

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Figure 5-4. Tacoma City Water Green River watershed forest management zones.

BACK PAGE OF AN 11 BY 17 FOLDOUT MAP.]

by Tacoma in the future and added to the HCP (in accordance with provisions of the Implementation Agreement), Tacoma and the Federal Services will review the newly acquired lands and place them into the management zone that is most consistent with the three objectives stated above (i.e., water quality, habitat, and timber revenues, in order of priority).

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-01B

MEASURE: Natural Zone

Tacoma will conduct no timber harvesting in those portions of the Upper HCP Area designated as Natural Zone, except to modify fish or wildlife habitat (with prior review by WDFW, and written approval of the USFWS and NMFS) or to remove danger trees within 150 feet of roads. This zone contains 5,850 acres. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to identify and appropriately manage these lands in the upper Green River watershed most important to the maintenance of surface water quality.

Rationale and Ecosystem Benefits

The Natural Zone encompasses lowlands directly adjacent to the Green River, Howard Hanson Reservoir, other lakes, and major tributary streams, where intensive forest practices could have a negative impact on water quality. This zone extends upland from the ordinary highwater mark of these waterbodies for a minimum of 200 feet, or until encountering a property boundary or major physical boundary (e.g., road or powerline right-of-way). The Natural Zone also includes two large blocks of upland mid-successional forest (80 to 90 years old) considered important to spotted owl conservation in the region. Management in the Natural Zone will be directed at preserving the health and vigor of the vegetative cover to reduce erosion and provide habitat for fish and wildlife. The long-term goal for the zone is to let forest stands develop into late-seral conditions through natural forest succession. No timber harvesting will occur in the Natural Zone, except for the selective removal of danger trees within 150 feet of roads, and harvest activities specifically conducted to improve habitat for one or more fish or wildlife species. If these do occur, they will be reviewed by the WDFW and Services, and approved in advance by the Federal Services to ensure they are consistent with this HCP.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-01C

MEASURE: Conservation Zone

Tacoma will conduct no even-aged harvesting in conifer-dominated stands (> 50 percent conifer species by basal area) in the Conservation Zone, and no harvesting of any kind (except selective removal of danger trees within 150 feet of roads and habitat modification that complies with snag, green recruitment tree and log retention standards in Measures HCM 3-01F and 3-01G) in conifer-dominated stands over 100 years old in the Conservation Zone (where stand age is determined as the average age of dominant and codominant trees). Any habitat modification in conifer dominated stands over 100 years old will be reviewed by the WDFW and approved in advance by the USFWS and NMFS. Tacoma may conduct uneven-aged harvesting in conifer-dominated stands less than 100 years old for the purpose of accelerating and/or enhancing the development of late-seral forest conditions. When conducting uneven-aged harvesting, Tacoma will leave a minimum of 50 healthy dominant or co-dominant conifers per acre (where available) dispersed across the harvest unit, and individual openings of no more than 10 acres. Green recruitment trees left to meet the requirements of snag and green recruitment tree retention will count toward the 50 trees left to meet this measure. Tacoma will conduct uneven-aged harvesting on an average of no more than 2 percent of the conifer-dominated stands in the Conservation Zone per year, averaged over the term of the HCP, unless a higher rate of harvest is necessary to meet fish and wildlife habitat or water quality goals reviewed by WDFW and approved by USFWS and NMFS. The maximum size of uneven-aged harvest units will be 120 acres. This zone contains 5,180 acres. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to identify and appropriately manage lands in the upper Green River watershed where active manipulation of the vegetation (including logging) can be used to improve habitat for fish and wildlife.

Rationale and Ecosystem Benefits

The Conservation Zone lies directly upland of the Natural Zone and includes a number of forested lands, powerline rights-of-way, open fields, rock outcrops, and wetlands. The long-term goal for the Conservation Zone is similar to the Natural Zone (maintenance of late seral-forest), but a wider range of management tools is allowed in the Conservation Zone because of reduced sensitivity to potential water quality impacts from forest practices. No timber harvesting (except selective removal of danger trees within 150 feet of roads and habitat improvements) will occur in late-seral forest stands (those over 100 years old), and only uneven-aged harvesting methods will be used in younger coniferous

forest stands. There will be no clearcutting larger than 10 acres in young coniferous stands, and uneven-aged harvesting will be done only for the purpose of accelerating the development of late-seral conditions. Once conifer stands in the Conservation Zone reach an age of 100 years, there will be no further harvesting other than selective removal (or topping when it is safe) of danger trees within 150 feet of roads and habitat modifications approved in advance by the Services. The uneven-aged harvest retention standard of 50 or more healthy dominant or co-dominant trees per acre will ensure sufficient trees are remaining after harvest to develop into a fully stocked stand of large trees by the time the stand is 100 years old. Although uneven-aged harvesting is considered largely a habitat improvement measure in this zone, Tacoma will limit the harvest that occurs in any one year to an average of 2 percent of the total conifer-dominated stands in the zone. This will provide a safeguard on water quality.

Stands dominated by hardwood species in the Conservation Zone may be converted to conifers (through clearcutting) as further habitat improvement, but this will only occur on sites capable of supporting coniferous forest stands. Once converted to conifers, those stands will only be subjected to uneven-aged harvesting, if necessary, until age 100, and no harvest (other than danger tree removal and habitat improvement) will occur after age 100.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-01D

MEASURE: Commercial Zone

Tacoma will manage coniferous forest stands in the Commercial Zone on an even-aged harvest rotation of 70 years. Tacoma will conduct even-aged harvesting of stands dominated by coniferous trees (> 50 percent conifer species by basal area) only when stands are at least 70 years old, and will conduct even-aged harvesting on an average of no more than 1.5 percent of the conifer-dominated stands in the Commercial Zone per year, averaged over the term of the HCP. When conducting commercial thinning in the Commercial Zone prior to even-aged harvest, Tacoma will leave a minimum of 50 healthy dominant and codominant coniferous trees per acre, where available, and will comply with the snag, green recruitment tree and log retention standards of Measure HCM 3-01G. This zone contains 3,858 acres. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to identify and appropriately manage lands in the upper Green River watershed where commercial timber harvest can occur without impacting surface water quality or significantly affecting fish and wildlife habitat.

Rationale and Ecosystem Benefits

The Commercial Zone includes those areas upland of the Natural and Conservation zones where forest practices can occur consistent with the protection of water quality and maintenance of fish and wildlife habitat. The objective in this zone is to grow and harvest commercial timber on a sustainable basis while minimizing impacts to water quality, fish and wildlife, and their habitats. Tacoma will manage coniferous forest stands in this zone on a 70-year, even-aged rotation, which is roughly 1.6 times the average commercial forest rotation in western Washington. This will result in a low average rate of harvest in the zone (1.5 percent per year) and will eventually lead to an even distribution of second growth forest age classes within the zone.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-01E

MEASURE: Hardwood Conversion

Stands in the Conservation Zone and Commercial Zone dominated by hardwood species (> 50 percent hardwoods by basal area) on sites capable of producing conifers of commercial size (Douglas-fir 50-year site index ≥ 80) may be converted to conifers by clearcutting the existing trees and replanting with conifers as specified in the reforestation HCM. There will be no limit on the number of acres of hardwood-dominated stands that can be harvested and converted to conifers in a given year. All other even-aged harvest measures in this HCP will apply to hardwood conversions. Hardwood conversion will not occur in no-harvest riparian buffers. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to encourage the conversion of hardwood forest to coniferous forest in order to improve surface water quality and enhance habitat for fish and wildlife.

Rationale and Ecosystem Benefits

Hardwood species such as red alder (*Alnus rubra*), bigleaf maple (*Acer macrophylum*), and black cottonwood (*Populus trichocarpa*) are natural components of the coniferous forest landscape in western Washington, but their abundance has increased significantly over the past century as a result of commercial timber harvest. Where they were once limited to sites with moist soils and/or frequent natural disturbances (such as forested wetlands and low-gradient stream corridors), they are now common on upland sites where alteration of soil conditions and/or poor regeneration practices in the past have delayed the return of coniferous species that existed prior to harvest. The Upper HCP Area will continue to support these hardwood tree species (and the wildlife that utilize

them) in riparian corridors, forested wetlands, upland sites with frequent disturbances and throughout the Natural Zone, but other sites that supported mature conifer stands prior to earlier timber harvesting will be converted back to conifers by clearcutting existing hardwoods and replanting with seedling Douglas-fir (*Pseudotsuga menziesii*) or other suitable conifers. The eventual benefits to fish and wildlife will be those associated with the presence of late-seral coniferous forest habitat (in the Conservation Zone) and second-growth coniferous forest (in the Commercial Zone).

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-01F

MEASURE: Salvage Harvesting

Tacoma may conduct salvage timber harvesting in forested areas affected by windthrow, insect infestation, disease, or fire, subject to the following conditions:

- No salvage harvesting will occur in the Natural Zone or in stands over 100 years old in the Conservation Zone, except for selective removal (or topping when it is safe) of trees within 150 feet of roads. Danger trees felled in the Natural Zone will be left as wildlife habitat, or removed to be used elsewhere to meet one or more of the Conservation Measures of this HCP.
- No salvage harvesting will occur within no-harvest portions of riparian or wetland buffers, or within forested areas with a Douglas-fir 50-year site index of ≤ 80 (i.e., Upland Management Areas). **Danger trees felled within no-harvest riparian buffers will be placed on the streamside portion of the buffer.**
- Individual salvage harvest areas will include no more than 120 contiguous acres**.** ~~without prior coordination with the WDFW, USFWS, and NMFS.~~
- Salvage harvesting will be conducted in a manner that complies with the snag, green recruitment tree and log retention requirements of Measure HCM 3-01G**, except the total number of safe snags required to be left will not exceed six per acre**.
- Salvage harvesting in stands less than 100 years old in the Conservation Zone will be conducted in a manner that complies with the uneven-aged harvesting requirements of Measure HCM 3-01C, except there will be no limitation on the number of acres of salvage harvesting in any year.
- Salvage harvesting may occur in stands less than 100 years old in the Conservation Zone when insects, fire, windthrow, or disease reduces total canopy closure to less than 40 percent over 2 or more acres.
- Salvage harvesting may occur in the Commercial Zone when insects, fire, windthrow, disease, or flood reduces total canopy closure to less than 40 percent over 2 or more acres. Tacoma will fund all the costs associated with this measure**.**

- **No tree, or portion of a tree, that has entered the stream channel will be salvaged.**
- **Live healthy coniferous trees will not be felled during salvage harvesting unless such felling is necessary to access and remove dead and damaged trees in a safe and economical manner**.

Objective

The objective of this measure is to protect surface water quality and habitat for fish and wildlife by establishing restriction on the salvage harvest of timber.

Rationale and Ecosystem Benefits

Salvage harvesting will help maintain the health of the forest in the Commercial Zone and contribute to the economic return from these lands, ultimately benefiting the other watershed management programs that require funding. However, salvage harvesting can have negative impacts on water quality and habitat if not conducted properly. Measures are therefore necessary to avoid any negative impacts of salvage harvesting.

No salvage harvesting will occur within no-harvest riparian buffers, or in areas not suited to commercial production of conifers (i.e., those with a site index ≤ 80). Salvage harvesting will also be restricted in the Natural Zone and in stands over 100 years old in the Conservation Zone because it is counter to the objective of creating and maintaining late-seral forest conditions. In the Commercial Zone and the remainder of the Conservation Zone, fire, wind, or disease must reduce the canopy closure below 40 percent over 2 or more acres before salvage harvesting can occur. This will limit salvage operations to those instances where there is the potential for a significant area within the zone to be without a forest cover as a result of disturbance. Smaller disturbances, and all disturbances caused by flooding in the Conservation Zone, will be allowed to recover naturally without intervention or salvage harvesting.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-01G

MEASURE: Snags, Green Recruitment Trees, and Logs

When conducting even-aged harvesting, uneven-aged harvesting, or commercial thinning ~~or salvage harvesting~~ in the Upper HCP Area, Tacoma will retain all safe snags and at least four green recruitment trees (≥ 12 inches dbh) and four logs (≥ 12 inches diameter; ≥ 20 feet long) per acre, where available. At least one of the green recruitment trees will be ≥ 20 inches dbh, and another will be ≥ 16 inches dbh. If

sufficient green recruitment trees of this size are not available, the largest available green trees will be left. No more than two of the green recruitment trees can be hardwoods. Preference will be given to leaving large, live defective green recruitment trees. If at least six safe snags (≥ 12 inches dbh; ≥ 20 feet tall) are not available per acre of harvest, additional green recruitment trees (≥ 12 inches dbh) will be left at a replacement ratio of 1 to 1. If at least two safe snags ≥12 inches dbh and ≥ 20 feet tall are not available per acre of harvest in stands with an average stand dbh ≥ 12 inches, up to two of the green recruitment trees will be topped, girdled, inoculated with fungus or otherwise killed to create new snags at the time of harvest. Green recruitment trees will be killed at a replacement ratio of 1 to 1, so that at least two snags or recently killed recruitment trees are left per acre of harvest, averaged over the harvest unit. Snags and green recruitment trees will be scattered or clumped within harvest units, depending on pre-harvest distribution, harvest limitations, safety and likelihood of long-term survival. In the Commercial Zone, the preferred method will be to leave snags and green recruitment trees in clumps along stream and wetland buffers, adjacent to Upland Management Areas (UMAs) or along harvest unit boundaries. In the Conservation Zone, Tacoma will attempt to leave snags more evenly distributed among the 50 or more dominant or codominant trees remaining after harvest. In the Natural Zone all snags will be allowed to persist naturally unless determined to be safety hazards in accordance with Measure HCM 3-01F. The distance between clumps will be no greater than 600 feet. Clumps will include 10 or more snags and/or green recruitment trees, and 4 or more logs. Snags and green trees left to meet riparian buffer requirements or left in UMAs will count toward meeting the requirements of this measure for one harvest unit directly adjacent to each riparian buffer or UMA. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to protect and enhance habitat for cavity-dwelling wildlife in the upper Green River watershed.

Rationale and Ecosystem Benefits

Snags, residual live trees, and logs provide several essential habitat elements to fish and wildlife. Snags and large trees in riparian areas contribute LWD for instream cover, pool formation, sediment trapping, bank stabilization, and nutrient input. Snags, large trees, and logs in riparian and upland areas also provide nests, burrows, perches, and foraging substrate for a wide range of wildlife species, some of which would not occur in a given area without the presence of these habitat features. Most wildlife species covered by this HCP make use of snags, large trees and/or logs; two (Vaux's swift and pileated woodpecker) are dependent on them. In the past, common practice in the Pacific Northwest was to eliminate snags, large trees, and logs during timber harvest because they presented hazards to worker safety, interfered with harvest operations, occupied

space potentially available to new tree seedlings, and/or had commercial value if removed from the forest. These concerns still exist today, but Washington Forest Practices Rules and Regulations now require retention of certain numbers of snags, trees, and logs at the time of even-aged harvest, subject to maintaining safe and economic working conditions. The measure for snag, green recruitment tree, and log retention in this HCP is double the current state requirement in terms of the number of pieces to be retained. This HCP measure also requires that at least some of the trees be of a larger size than required under state regulation. The maximum allowable spacing between snags and green recruitment trees is also less in this HCP than in state regulations, to account for species with small home ranges that may require these habitat elements to be distributed more evenly across the landscape. The two HCP species of most concern relative to snags (Vaux's swift and pileated woodpecker) are addressed in species-specific measures elsewhere in this HCP.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-01H

MEASURE: Harvest Unit Size

Even-aged harvest units (i.e., clearcuts) in the Upper HCP Area will not exceed 40 acres in size. Uneven-aged and salvage harvest units will not exceed 120 acres in size without prior review by WDFW and approval by the USFWS and NMFS. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to minimize the effects of timber harvest on water quality, fish, and wildlife by limiting the size of individual harvest units.

Rationale and Ecosystem Benefits

Even-aged harvesting is an essential management tool in western Washington, where commercially valuable coniferous species such as Douglas-fir are intolerant of shade and will not regenerate under existing forest canopies. Even-aged harvesting is also environmentally less damaging under certain circumstances because it can be conducted with fewer roads and less ground impact on steep slopes than can uneven-aged harvesting. However, even-aged harvesting can be detrimental to water quality and fish and wildlife habitat if conducted in large harvest units or in multiple small units over a very short period of time. To avoid such impacts, even-aged harvest units in the Upper HCP Area will be limited to 40 acres in size.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-01I

MEASURE: Even-aged Harvest Unit Adjacency Rule

Even-aged harvesting will only occur when the surrounding forestland is fully stocked with trees a minimum of five years old or a minimum of 5 feet high. This measure will not apply to lands incapable of supporting fully stocked forest stands or lands converted to a non-forest use adjacent to harvest units. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to minimize the effects of timber harvest on water quality, fish, and wildlife by limiting the rate of harvest in a local area.

Rationale and Ecosystem Benefits

As noted under other habitat conservation measures, even-aged harvesting can be conducted with minimal impact to water quality and habitat if the size of harvest units is limited. This measure exceeds current Washington State Forest Practices Rules and Regulations, which require that at least 90 percent of the perimeter of a harvest unit be surrounded by trees at least five years old or at least 4 feet tall, and that the stands of surrounding forest be at least 300 feet wide. Proposed habitat conservation measures, combined with the limited area in which even-aged harvesting occur (Commercial and Conservation zones only) and the very low rate of harvest (average of 1.5 to 2.0 percent per year by zone, respectively), ensure that the negative effects of even-aged harvesting will be avoided in the Upper HCP Area.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-01J

MEASURE: Harvest Restrictions on Sites with Low Productivity

Timber harvesting in the Upper HCP Area will occur only on lands with a Douglas-fir 50-year site index of 80 or greater. Lands with lower site indices will be designated as Upland Management Areas (UMAs) and managed without timber harvest for the term of the HCP. Snags and green trees left in an UMA will count toward meeting the requirements of HCM 3-01G for one harvest unit directly adjacent to each UMA. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to minimize the long-term ecological impacts of timber harvest by restricting harvest on sites with low productivity.

Rationale and Ecosystem Benefits

Timber harvesting in the Upper HCP Area will occur only on sites capable of sustained timber production under a 70-year, even-aged rotation. For purposes of this HCP, harvestable sites are defined as those with a Douglas-fir 50-year site index of 80 or greater. Site index is the height (in feet) that a dominant tree of a given species will reach within the specified period of time. Site index for Douglas-fir at 50 years in the western Washington Cascades can be as high as 160, but most commercial stands have site indices between 80 and 140. Sites with lower productivity are still capable of producing trees of commercial size, but the sites are often expensive to harvest, difficult to regenerate, and susceptible to water quality impacts because of erodable and/or easily compacted soils. They are not well suited to repeated harvesting at 70-year intervals. To avoid the potential impacts associated with harvesting and subsequent regeneration of these areas, Tacoma will protect them from harvest and retain them as permanent habitat. There are approximately 103 acres in the Conservation Zone and 150 acres in the Commercial Zone that have been set aside as UMAs. They range in size from 1 to 30 acres, and are mostly dominated by Douglas-fir growing on thin soils.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-01K

MEASURE: Contractor, Logger, and Employee Awareness

All successful timber purchasers, loggers, and other forestry contractors operating in the Upper HCP Area will be provided copies of the pertinent HCP measures and required to comply with all relevant terms and conditions of the HCP while conducting any activities in the Upper HCP Area. All full-time Tacoma employees working in the Upper HCP Area will be instructed in the identification of all species covered by this HCP and their nests, dens, and preferred habitat. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to ensure successful implementation of the Tacoma HCP by informing and instructing employees and contractors working in the HCP Area.

Rationale and Ecosystem Benefits

The effectiveness of this HCP will ultimately depend on the successful implementation of all mitigation measures in the field. To that end, all operators, contractors and full-time Tacoma employees working in the Upper HCP Area will be provided the necessary information to ensure they conduct their activities in compliance with the HCP.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-01L

MEASURE: Logging Slash Disposal

Tacoma will burn no logging slash in the Natural Zone, unless the burning is part of a habitat modification effort reviewed by WDFW and approved in advance by the USFWS and NMFS. Logging slash generated during timber harvesting operations in the Conservation and Commercial zones may be treated by mechanical- and/or hand-piling followed by burning (both zones), or by broadcast burning (Commercial Zone and powerline rights-of-way within the Conservation Zone only). Harvested areas on slopes of 30 percent or less may be mechanically scarified with low-ground-pressure tractors if slash and/or brush interfere with replanting. No mechanical scarification will occur on slopes greater than 30 percent. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to minimize the effects of timber harvest on water quality and habitat for fish and wildlife by restricting the burning of logging slash.

Rationale and Ecosystem Benefits

Harvest-related slash (tree tops, limbs, bark, and brush) can create a fire hazard and interfere with forest regeneration. Burning is an effective means of eliminating slash, preparing soils for regeneration, and reducing future competition between brush and tree seedlings. Burning can have negative impacts, however, if it reduces soil fertility, contributes to soil erosion, and eliminates snags, logs, and shrub cover that can provide fish and wildlife habitat. Tacoma will conduct no slash burning in the Natural Zone, unless specifically prescribed as a habitat improvement measure. In the Conservation Zone, Tacoma will burn slash only in piles (i.e., no broadcast burning except under powerline rights-of-way to improve forage) to avoid soils impacts and allow for the retention of snags, logs, and brush outside piles. In the Commercial Zone, the use of broadcast burning will be minimized to those areas where it is necessary to reduce fire hazard and achieve adequate regeneration. Pile burning will be the preferred method of slash disposal in the remainder of the Commercial Zone. Mechanical scarification, which is an alternative to burning, will be employed where it will achieve the same results as burning without the negative impacts to soils and habitat. Mechanical scarification can lead to problematic erosion on steep slopes, so Tacoma will conduct no mechanical scarification on slopes over 30 percent.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-01M

MEASURE: Reforestation

All even-aged harvest areas will be replanted with 300 to 400 suitable tree seedlings per acre by the first spring following harvesting. Douglas-fir will be the preferred species for planting, but shade-tolerant western hemlock, western red cedar, or true fir will be planted on sites not suitable for Douglas-fir. Openings in uneven-aged harvest areas will be replanted with 50 to 100 shade tolerant conifers per acre. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to ensure long-term productivity and optimal habitat benefits of commercial timberlands in the upper Green River watershed by requiring reforestation after harvest.

Rationale and Ecosystem Benefits

Quick and effective regeneration of harvested areas will be important to meeting the HCP objectives of maintaining water quality and providing habitat for fish and wildlife. Tacoma will replant harvest units at the earliest logical date (the first spring following harvest, when conditions are favorable for seedling establishment) and will plant sufficient numbers of seedlings of the appropriate species to achieve a healthy, diverse forest stand in the shortest time practical.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-01N

MEASURE: Harvest on Unstable Slope

Tacoma will conduct harvest activities on unstable landforms in accordance with prescriptions developed through Watershed Analysis, unless the Watershed Analysis prescription(s) would be less restrictive than one or more HCP measures specific to timber harvest. Tacoma personnel responsible for harvest unit layout will receive field training in the identification of potentially unstable landforms. ~~Tacoma will fund 100 percent of the costs associated with this measure.~~

In WAUs where a slope stability assessment and draft and final prescriptions have not been completed through the formal WDNR watershed analysis process within two years of issuance of the ITP, Tacoma will fund the assessment and mapping of lands within the Tacoma ownership using landforms described in previous analyses, or by identifying new landforms if necessary. Interim prescriptions completed to fulfill commitments made in this HCP will equal or exceed existing state rules and will be submitted to the DNR for review via the usual **Forest Practices Application** ~~EPA~~ Class IV special permit process and be approved by the Services. Draft prescriptions

developed to address slope stability associated with timber harvest on similar landforms in the Lester, Howard Hanson/Smay and Upper Green/Sunday Watershed Analyses will be applied until official Watershed Analyses have been completed and approved. **Tacoma will fund 100 percent of the costs associated with this measure.**

Objective

The objective of this measure is to protect long-term productivity of commercial timberlands in the upper Green River watershed and minimize the effects of timber harvest on water quality and fish habitat by restricting timber harvest on sites with a fish potential for slope failure.

Rationale and Ecosystem Benefits

Mass wasting assessments conducted to date in the upper Green River HCP Area have identified a relatively consistent suite of landforms that are considered to have a moderate to high mass wasting potential. These landforms, called Mass Wasting Mapping Units (MWMUs) include earthflow toes, bodies and scarps; inner gorges; headwalls; glaciofluvial terrace escarpments, and steep undissected hillslopes in various geologic units (Plum Creek 1996; USFS 1996).

Maps depicting the general location of the MWMUs have been completed for five of the six WAUs in the upper Green River HCP Area, and prescriptions have been developed to reduce the risk of future management-related mass wasting from those MWMUs with a moderate to high mass wasting potential (Appendix D). Implementation of many of those prescriptions requires field delineation of the mapping units. The descriptions of the MWMUs are intended to be used as a guide to delineate the actual boundaries of the map unit in the field during layout of proposed harvest units. To facilitate identification of potentially unstable mapping units, Tacoma will require employees or contractors responsible for harvest unit layout to attend a field course in the identification of unstable slopes at least once every five years.

Draft and final prescriptions developed to date require field mapping of inner gorges, headwalls, zero-order basins with slopes > 70 percent, and areas of active mass-wasting or potential instability. Harvest units located on steep zero-order basins, snow avalanche chutes, slump/earthflow toes, escarpments along the Green River, and within bedrock hollows or within 100 feet of recent slumps that feed into inner gorges or linear draws in canyons of mainstem tributaries must be reviewed by a slope stability specialist. No harvest will be allowed in headwalls, inner gorges (extending 20 feet beyond the slope

break or at least 50 feet from the ordinary high water mark where no slope break is present), within one crown width (approximately 20 feet) of steep Type 4 and 5 streams with sideslopes >70 percent on slump/earthflow bodies or within 20 feet of active landslides.

Tacoma will implement existing draft and final watershed analysis prescriptions upon issuance of the ITP regardless of whether the analyses have been formally approved by the Washington Department of Natural Resources (WDNR). Upon completion and approval of future Watershed Analyses, Tacoma will implement any additional prescriptions that may be approved.

In WAUs where assessments have not yet been completed, Tacoma will utilize descriptions of landforms developed for other WAUs within the upper Green River watershed to map and assess slope stability on lands within the HCP Area, or will develop new landform descriptions if necessary. The assessment will be completed by a slope stability specialist certified to conduct a Level 2 Mass Wasting Analysis under the WDNR training program. Until formal watershed analyses have been completed and approved, Tacoma will implement prescriptions that have been developed and approved for similar landforms in adjacent WAUs.

5.3.2 Habitat Conservation Measure: HCM 3-02 Riparian Management Measures

RIPARIAN MANAGEMENT MEASURES

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-02A

MEASURE: No-Harvest Riparian Buffers

In addition to the general harvesting restriction in the Natural Zone (HCM 3-01B), the limitation on harvesting in the Conservation Zone (HCM 3-10C) and the implementation of a 70-year sustainable harvest rotation in the Commercial Zone (HCM 3-01D), Tacoma will retain no-harvest riparian buffers along all streams and around wetlands in the Upper HCP Area. Minimum widths of riparian buffers will be as shown in Figure 5-5 and Tables 5-2 and 5-3. Riparian buffer widths may be increased (but not decreased) through a formal Washington State Forest Practices Board Watershed Analysis. ~~Harvest~~ **Timber management** activities will occur within no-harvest portions of riparian buffers only to modify fish or wildlife habitat or further other goals of this HCP, and only with prior review by WDFW and concurrence of the USFWS and NMFS. **Trees cut as a result of such activities will be left within no-harvest riparian buffers.**

Timber yarding may occur across Stream Type 4 and 5 riparian buffers, but such yarding will be limited to full or partial suspension cable yarding (no ground-based yarding) and will affect no more than 15 percent of the total length of buffer within or adjacent to a given harvest unit. Yarding corridors across landforms with a moderate to high mass wasting potential will be no wider than 30 feet and located on slopes < 80 percent with no indication of seasonal saturation or recent slope movement. Full log suspension will be utilized in all potentially unstable landforms and within 20 feet of stream channels in areas of high sediment delivery potential. Any trees within a riparian buffer that are killed or damaged by yarding operations will be left in the buffer (i.e., they will not be salvaged). Tacoma will fund all the costs associated with this measure. See following Figure 5-5 and Tables 5-2 and 5-3.

Objective

The objective of this measure is to protect and enhance water quality and habitat for fish and wildlife by timber harvest directly adjacent to streams.

Rationale and Ecosystem Benefits

Riparian zones are areas with unique soil, vegetation and resource values, comprised of an aquatic ecosystem, seasonally flooded banks or terraces and adjacent upland areas that have a direct influence on the aquatic habitat. Numerous authors have identified a need for riparian buffers along streams for the purpose of maintaining or enhancing key riparian functions (Bisson 1987; Castelle et al. 1994; Belt and O'Loughlin 1994). One of the primary functions of the riparian buffer is the recruitment of large woody debris (LWD). McDade et al. (1990) observed that ninety percent of the LWD delivered to streams in unmanaged, mature Douglas-fir/hemlock stands in western Washington and Oregon were derived from within 100 feet of the stream channel. Similar studies by Murphy and Koski (1989) in old-growth Sitka spruce and hemlock forests southeast Alaska indicate that 99 percent of the in-channel LWD was recruited from 100 feet of the stream. Robison and Beschta (1990) suggested that buffer strips with widths on each stream bank at least equal to tree height would provide for maximum amounts of LWD. LWD loading is related to the number of mature trees along the stream, and to local geologic and channel morphologic conditions (Martin in press; Keller et al. 1995).

Trees and undisturbed understory vegetation within riparian buffers also stabilize banks, filter sediment, and provide shade and nutrients. The contribution of root strength to maintenance of bank stability declines at distances greater than one-half the crown diameter (Burroughs and Thomas 1977). Filter strips 200 to 300 feet wide are generally effective in controlling sediment that is not channelized (Haupt 1959). Broderson (1973) found that buffers 200 feet wide effectively controlled sedimentation, even on steep

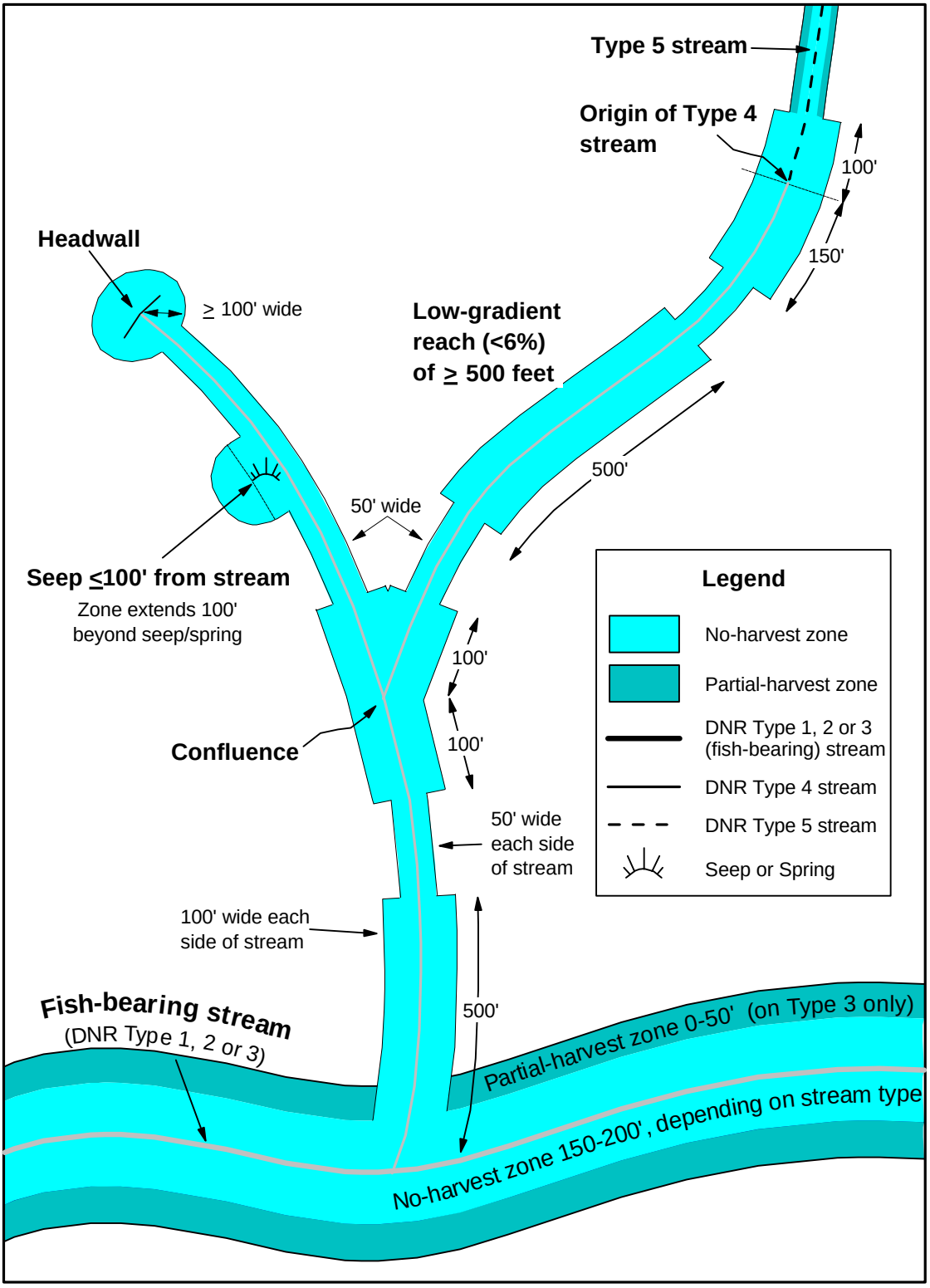

Figure 5-5. Diagram of Type 4 stream buffer zone implementation.

Table 5-2. Stream buffer widths for the Tacoma Green River HCP.

DNR Stream Type [1]	No-Harvest Buffer Width [2, 4]	Partial-Harvest Buffer Width [3, 4]
Types 1 and 2	200 feet	0
Type 3	150 feet	50 feet
Type 4	50 to 100 feet [4,5]	0
Type 5	25 feet	25 **feet**

[1] All streams (currently mapped or unmapped) within 200 feet of a proposed forest practice will be evaluated in the field in accordance with current Washington Forest Practices Rules and Regulations prior to submission of a Forest Practices Application to determine if they should be re-classified.

[2] Buffer width will be measured horizontally from the **edge of a streambank full width or the outer edge of its** ~~ordinary highwater mark~~, channel migration ~~zone, or channel~~ disturbance zone, whichever is greater, along each side of the stream. Buffer width around Howard Hanson Reservoir will be measured horizontally from elevation 1,177 feet above mean sea level. **Only fish and wildlife habitat mitigation work will be allowed to occur in this buffer.**

[3] Partial-harvest buffer width will be measured horizontally from the outer edge of the no-harvest zone along each side of the stream. **Partial harvest will leave not less than the 70 largest conifer trees per acre in buffers along Type 3 waters, and not less than the 50 largest conifer trees per acre in buffers along Type 5 waters.**

[4] **The presence of road or right-of-way will not affect width of buffers. Only that portion of any wood protruding within ten feet of the road tread can be cut to eliminate a safety hazard.**

[5] The no-harvest buffer along Type 4 streams will be a minimum of 50 feet wide, and will be expanded to 100 feet wide:

- at the **upstream** origins of Type 4 streams (including 100 feet upstream and 150 feet downstream);
- at headwalls and along steep and unstable slopes (this width may be further increased by watershed analysis);
- at confluences with other Type 4 streams (including 100 feet upstream and 100 feet downstream);
- at confluences of Type 4 streams with fish-bearing streams (including 500 feet upstream);
- around springs and seeps within 100 feet of Type 4 streams; and
- along low-gradient reaches of Type 4 streams (i.e., those with a gradient of ≤ 6 percent for 500 or more contiguous feet).

Table 5-3. Wetland buffer widths for the Tacoma Green River HCP.

Wetland Type [1]	Wetland Size	No-Harvest Buffer Width [2]
Non-forested Wetlands with ³ 0.5 acre open water		
Type A (all)	> 5.0 acres	200 feet
Type A (all)	0.5 to 5.0 acres	100 feet
Type A (bogs/fens only)	0.25 to 0.5 acre	100 feet
Non-forested Wetlands with < 0.5 acre open water		
Type B (all)	> 5.0 acres	100 feet
Type B (all)	0.25 to 5.0 acres	50 feet
Forested Wetlands(>30 percent canopy cover)		
Type C (all)	> 5.0 acres	50 feet
Type C (all)	0.5 to 5.0 acres	25 feet

[1] All wetland definitions follow Washington Forest Practices Rules and Regulations, WAC 222-16-035, effective July 1995.

[2] Buffer width will be measured horizontally from the edge of the wetland.

slopes. The effectiveness of the riparian buffers at providing shade varies with topography, channel width and orientation, and forest structure, particularly the extent of both understory and overstory vegetation (USDA et al. 1993). As with shade, the distance away from the stream from which litter inputs originate depends on site specific conditions, but riparian forests of widths equal to or greater than 100 feet are believed to be sufficient to maintain nutrient inputs and biotic community structure in streams (USDA et al. 1993).

Riparian forest also plays an important function as habitat for plants and animals. Due to their high overall productivity and their wide range of gradients, aspects, soils and moisture conditions, riparian forests support a diversity of plant and animal life that typically exceeds that of the adjacent upland and aquatic habitats (Odum 1971). Riparian forests provide thermal cover for streamside amphibians that require cool, moist habitats; travel corridors for species that hunt along streams and/or have very large home ranges (e.g., Pacific fisher); and escape cover for most other species that travel to streams on a regular basis for water (Thomas 1979; Taber 1976; Tabor 1976). Riparian forests often also have higher diversities and densities of understory plant life than surrounding uplands, thereby providing habitat to certain birds and mammals that cannot be found in uplands (Stevens et al. 1977). In the shifting mosaic of a managed forest landscape, riparian areas can serve important habitat functions by providing both a stable source of closed-canopy forest and edge habitat at the interface between the riparian forest and recent clearcut.

The upper Green River HCP Area contains ~~146~~ **approximately 110** miles of streams (Table 5-4). Except for the presence of the Green River (including Howard Hanson Reservoir) and its major tributaries in the Natural Zone, the distribution of total stream miles is roughly equivalent among the three management zones. The distribution of stream miles among the DNR stream types is typical of western Washington, with Type 1 and Type 5 being the most abundant.

All 65.11 stream miles in the Natural Zone will be protected because, in accordance with Measure HCM 3-01B, there will be no commercial forestry. Habitat alteration will occur in the Natural Zone only to improve fish and/or wildlife habitat, and only with the prior approval of the Services. Harvesting will take place on a limited basis in the Conservation Zone, and to a greater (although still limited) basis in the Commercial Zone. Measures specific to the protection of riparian and aquatic habitats are appropriate for these zones. Measure HCM 3-02A therefore calls for no-harvest zones of 25 to 200 feet in width along each side of streams in the HCP Area, the width depending on the stream type. Along larger streams (DNR Types 1, 2 and 3) where stream temperature,

LWD and streamside habitat are most critical, no-harvest buffers will be at least 150 feet wide (exceeding the minimum recommendations of Murphy and Koski (1989), USDA (1993) and others. On smaller perennial streams (DNR Type 4) the no-harvest buffers will be at least 50 feet wide, and it will be expanded to 100 feet wide at all sensitive areas such as confluences, low-gradient reaches, seeps, headwalls and stream origins. Type 5 streams are the intermittent headwaters of larger streams. While they provide limited habitat themselves, they lead to larger waters downstream and contribute to the temperature, nutrient levels, and LWD in those larger streams. For those reasons, all Type 5 streams will also have no-harvest buffers of 25 feet in width.

Table 5-4. Stream miles within the upper Green River HCP Area.

DNR Stream Type	Miles of Stream			
	Commercial Zone	Conservation Zone	Natural Zone	All Zones
1	0.71	2.30	41.07[1]	44.08
2	0.08	0.00	0.15	0.23
3	3.06	4.27	8.32	15.65
4	4.81	7.53	5.95	18.29
5	11.95	10.54	9.62	32.11
Total	20.61	24.64	65.11	110.36

[1] Natural includes 7.92 miles of reservoir shoreline

The total area included within no-harvest riparian buffers ~~in the Commercial Zone and Conservation Zone~~ will be 2,126 acres (Table 5-5). In addition to maintaining riparian functions in all streams in the upper HCP Area, the no-harvest riparian zones will develop into a core of late-successional coniferous forest habitat available to riparian as well as upland wildlife species in the watershed. The 686 acres of no-harvest buffer included within the Commercial and Conservation Zones represent 9.8 percent of the total forested area within those (686 ÷ 7,025).

Cable yarding of harvested timber will be allowed through riparian buffers along Type 4 and 5 streams in the Commercial and Conservation zones to minimize the amount of new road construction in these areas. Given the high density of smaller streams in the HCP Area, it is difficult, if not impossible, to reach all harvestable areas without either building temporary logging roads or lifting felled timber across streams with cable yarders. Forest roads have been identified as a major contributor to stream sediment in western Washington, so it is one objective of this HCP to minimize new road construction. This will necessitate occasional yarding across streams. All yarding will be done by cable, with one or both ends of the log suspended above the ground, so soil

disturbance will be minimized. The typical result will be damage (i.e., limb breakage and/or topping) of trees in the yarding corridor. With the long harvest rotations of 70 years or more in the HCP Area (i.e., long return intervals for any one stream segment) and the limitation of no more than 15 percent disturbance to any stream segment, the impacts of yarding across stream corridors will be more than offset by the benefits of reducing new road construction.

Table 5-5. Acres of habitat included within riparian management zones in the upper Green River HCP Area.

DNR Stream Type	No-harvest Buffer Width (feet)	Partial-harvest Buffer Width (feet)	Acres of Commercial Zone [1]	Acres of Conservation Zone [1]	Acres of Natural Zone	Total Acres [1]
1	200	0	123	89	1158	1370
2	200	0	2	0	4	6
3	150	50	148 (+ 49)	103 (+ 34)	188	439 (+ 83)
4	≥50	0	56	59	48	163
5	25	25	68 (+ 68)	38 (+ 38)	42	148 (+ 106)
Total			397 (+ 117)	289 (+ 72)	1440	2126 (+ 189)

[1] Numbers in parentheses reflect acres in partial-harvest buffers.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-02B

MEASURE: Partial-Harvest Riparian Buffers

Tacoma will retain partial-harvest riparian buffers along Type 3 and 5 streams as specified in Table 5-2 and shown in Figure 5-5. Timber harvesting in partial-harvest buffers will comply with all other pertinent measures in this HCP, and will result in leaving the 70 largest coniferous trees per acre along Type 3 streams and the 50 largest coniferous trees per acre along Type 5 streams. At the time of partial-harvesting, preference will be given for leaving: 1) trees that are damaged and/or leaning toward the stream; 2) trees that, due to soil conditions, slope, or proximity to the stream, have a high likelihood of delivering LWD to the stream, 3) trees with deformities or other features that provide unique wildlife habitat elements; and 4) trees with signs of wildlife use (e.g., nests, cavities, foraging holes, etc.). All other considerations being equal, trees nearer the stream will be given preference over trees toward the outer edge of the riparian buffer, so that the density of leave trees may be higher near the stream and lower near the outer edge of the buffer.

Objective

The objective of this measure is to protect and enhance water quality and habitat for fish and wildlife by restricting timber harvest near riparian areas.

Rationale and Ecosystem Benefits

For all the reasons states under the rationale for Measure HCM 3-02A, forested riparian buffers are important to fish, wildlife and water quality. As a margin of safety on Type 3 and 5 streams, Tacoma will manage an additional 25 to 50 feet as partial-harvest beyond the no-harvest riparian buffers. These areas will provide additional LWD, shading and upland forest habitat along streams, to the benefit of species using these areas. More importantly, Tacoma will have the ability to enter these zones and encourage the development of large coniferous trees by removing hardwoods and smaller conifers. This will ultimately lead to improved conditions for both fish and wildlife. Given the post-harvest tree retention standards for these areas, and the long intervals between entries (70 years or more in the Commercial Zone, and no more than one entry total in the Conservation Zone) these areas will differ from adjacent no-harvest buffers for only one to two decades after harvest.

5.3.3 Habitat Conservation Measure: HCM 3-03 Road Construction and Maintenance Measures

ROAD CONSTRUCTION AND MAINTENANCE MEASURES

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-03A

MEASURE: Watershed Analysis

Tacoma will participate in all Watershed Analyses performed according to the Washington Forest Practices Board process for lands within the upper Green River HCP Area. Tacoma will implement all prescriptions prescribed through Watershed Analysis, unless they would be less restrictive than measures described in this HCP. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to encourage comprehensive watershed assessment and management in the upper Green River watershed.

Rationale and Ecosystem Benefits

In 1992, the Washington Forest Practices Board adopted a Watershed Analysis Process for developing individual watershed plans based on a comprehensive understanding of basin-wide processes (Chapter 222-22 WAC). The Watershed Analysis Process includes an evaluation of mass wasting, surface erosion, hydrology, riparian function, channel

geomorphology, fish habitat, public works, and water quality. It is a collaborative scientific process involving Tribes, resource specialists, landowners, agencies, and interested members of the public.

In a Watershed Analysis, qualified scientists gather information and develop interpretations of watershed processes, resource conditions, and sensitivities at the watershed scale. The basic premise of the analysis is that a change in sediment delivery, hydrology, or riparian function resulting from forest practices is significant when it is sufficient to cause an adverse change in a public resources (fish habitat, water quality, and public works). Risks to public resources are identified and supported with data generated by the analyst team. The results of a Watershed Analysis are presented using maps of sensitive areas and reports describing the nature of the sensitivity. Land managers and resource agency representatives use the information to develop management prescriptions that have been tailored to watershed conditions in response to resource concerns identified by the scientific investigation. Monitoring plans are often recommended to track the effectiveness of prescriptions and to provide feedback as to whether resource conditions are actually improving as a result of the prescriptions. Relevant data collected as part of the HCP monitoring process will be provided to analysts upon request.

Upon completion of the draft assessment report and prescriptions, an environmental checklist is completed, as required under the State Environmental Policy Act, and the report and prescriptions are forwarded to the WDNR Resource Protection and Service Assistant Regional Manager for Threshold Determination and Final Approval. Tacoma implements draft prescriptions once they have been completed, adjusting them as necessary if changes are made during the approval process. Products of the watershed analysis are assumed to be valid for five years, at which time the process may be repeated and prescriptions modified if necessary.

The existing Department of Natural Resources (DNR) Watershed Analysis Process is designed primarily to protect fish habitat, water quality, and capitol improvements of the state from impacts resulting from forest practices. The process provides protection for public resources through prescriptions designed for regulatory application. Problems or events not regulated by forest practices may also be identified in the analyst report. The process may identify opportunities for resource enhancement or restoration that can be undertaken voluntarily outside of regulation. Upland forest habitats for terrestrial plants and animals are protected only incidentally, although incidental protection can be substantial, especially for other aquatic species.

The state of Washington has been divided into Watershed Administrative Units (WAUs) ranging in size from 10,000 to 50,000 acres. The Green River HCP area contains six WAUs. The DNR is responsible for prioritizing and conducting Watershed Analyses. Individual landowners with more than 10 percent of the non-federal forest lands within a WAU may initiate a Watershed Analysis. Tacoma will actively participate in all Watershed Analyses performed according to the Washington Forest Practices Board process for lands in the upper Green River HCP Area. Active participation will include attending start-up, synthesis and hand-off meetings and supplying at least one prescription team member. Tacoma has been and is participating in five of the six watershed analyses that have been completed or are currently under way. Tacoma will also participate in the proposed North Fork **Green** Watershed Analysis scheduled to begin in July of **2000**~~1999~~. Appendix D contains an example of prescriptions governing surface erosion, mass wasting, and hydrology from the Lester WAU. Draft prescriptions developed to date for other WAUs are generally similar to the prescriptions contained in Appendix D. Table 5-6 summarizes the current status of State DNR Watershed Analyses in the upper Green River HCP Area in which Tacoma has participated or will participate.

Table 5-6. Status of watershed analyses in the upper Green River Basin as of February 1999.[1]

WAU	Acres	Start	Draft Assessment	Draft Prescriptions	SEPA	Final Assessment and Prescriptions
Lester **Creek**	32,803	10/11/94	9/11/95	3/25/96	7/29/96	3/16/98
Sunday **Creek**	15,571	7/10/95	6/97	2/99	~~*5/99*~~***12/00***	~~*8/99*~~***6/01***
Green **Headwaters**	23,688	7/10/95	6/97	2/99	~~*5/99*~~***12/00***	~~*8/99*~~***6/01***
Howard Hanson	46,501	10/23/96	~~2/99~~**6/97**[2]	2/99	~~*6/99*~~***3/01***	~~*9/99*~~***9/01***
Smay **Creek**	14,415	10/23/96	~~2/99~~**6/97**[2]	2/99	~~*6/99*~~***3/01***	~~*9/99*~~***9/01***
North Fork **Green**	17,728	*7/*~~*99*~~***00***	~~*10/99*~~***3/01***	~~*2/2000*~~***6/01***	~~*5/2000*~~***9/01***	~~*8/2000*~~***12/01***

[1] Italics indicate expected completion date.

[2] **Field work complete but reports not yet available for review.**

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-03B

MEASURE: Road Maintenance

Tacoma will continue to construct and maintain roads throughout all three zones in the Upper HCP Area (subject to compliance with other measures in this HCP) to facilitate

watershed management, forestry activities and implementation of this HCP. Within two years of issuance of the ITP, Tacoma will contribute funds and participate in the development of a Road Sediment Reduction Plan (RSRP) describing the priorities and schedule for road maintenance, improvement and abandonment activities that will be implemented to reduce road sediment inputs to less than 50 percent of the estimated natural background sediment production rate. The RSRP will include an evaluation of surface erosion concerns for roads in subbasins that currently have moderate to high estimated road sediment yields (>50 percent over background). In addition, all existing roads in areas with a moderate to high mass wasting potential will be reviewed by a specialist in slope stability and road construction/repair. The results of specialist's evaluation and proposed correction or mitigation activities will be included in the RSRP. The RSRP will include a prioritization and timetable for road repairs. Problems classified as high priority will be corrected by the third year following approval of the RSRP.

In WAUs where a watershed Analysis has been completed and approved, Tacoma will contribute funding for a road inventory and participate in the development of the RSRP in cooperation with other landowners in the WAU. Funding will be proportional to the percentage of land owned by Tacoma in each subbasin. In WAUs where a Watershed Analysis has not been formally approved within two years of issuance of the ITP, Tacoma will take primary responsibility for funding and preparation of a RSRP that covers roads on or used to access the Tacoma ownership.

Objective

The objective of this measure is to protect water quality and fish habitat in the upper Green River watershed through proper road maintenance.

Rationale and Ecosystem Benefits

Sedimentation of salmonid spawning habitat is a concern throughout the Pacific Northwest. A positive correlation has been observed between the area of logging roads in a basin and levels of fine sediment in downstream spawning gravel (Cederholm et al. 1981). As the level of fine sediment in spawning gravel increases, survival of salmonid eggs and fry declines (Tappel and Bjornn 1983; Reiser and White 1988; Young et al. 1991).

Surface erosion assessments performed for the Lester, Sunday, Green, Howard Hanson and Smay Watershed Analyses indicate that road-related sediment inputs currently exceed background levels by more than 50 percent in a number of subbasins in the upper Green River HCP Area. Sediment yield increases greater than 50 percent may be chronically detectable and have the potential to adversely effect aquatic resources (WFPB 1997). Final or draft prescriptions for Watershed Analyses conducted to date in the upper

Green River HCP Area call for each landowner to complete an RSRP that describes planned road maintenance, improvement and abandonment activities including the priorities and schedule for activities that will be implemented to reduce road sediment inputs. The RSRP must be submitted within one year following approval of the analysis. Plans must be submitted to WDNR each year until the objective of reducing road sediment delivery below 50 percent of background has been achieved. Sources of road erosion classified as high priority must be treated by the end of the third year following analysis. All remaining work prescribed under the plan must be treated within five years of approval. The road surface erosion model used in the Surface Erosion Module Version 3.0 shall be applied annually following completion of road maintenance activities to evaluate the adequacy of efforts implemented to satisfy the 50 percent background objective.

Mass wasting assessments conducted as part of the Lester, upper Green/Sunday, and Howard Hanson/Smay Watershed Analyses have also identified a relatively consistent suite of landforms that are considered to have a moderate to high mass wasting potential. These landforms include earthflow toes, bodies and scarps; inner gorges; headwalls; glaciofluvial terrace escarpments, and steep undissected hillslopes in various geologic units (Plum Creek 1996; USFS 1996). Draft and final prescriptions developed to date require that existing roads on landforms with a moderate or high mass wasting potential must be field evaluated by a specialist in slope stability and road construction/repair within one year of approval of the Watershed Analysis.

Landforms with moderate to high mass wasting potential have been mapped for five of the six WAUs in the upper Green River HCP Area. Those maps, and the corresponding descriptions of each mass wasting map unit will be used to determine the specific location of moderate to high hazard areas in the field, and in WAUs where Watershed Analysis assessments have not been completed. To facilitate accurate field identification of landforms with moderate to high mass wasting potential, Tacoma employees responsible for harvest unit and new road layout will receive training in field identification of unstable lands.

Tacoma will implement both draft and final watershed analysis prescriptions upon issuance of the ITP regardless of whether the analyses have been formally approved by WDNR. In WAUs where assessments have been approved, Tacoma is providing funding for a comprehensive road inventory and developing a RSRP in cooperation with other landowners. Funding for development of the RSRP, and for major maintenance activities is directly proportional to the percentage of land area owned by Tacoma that is tributary

to that road segment. Funding for annual maintenance is proportional to the annual use (i.e., number of loads hauled) by each land owner.

In WAUs where assessments have not yet been completed, Tacoma will assume that all subbasins have the potential for moderate increases in sediment yield (>50 percent) and that all landforms identified as having a moderate to high mass wasting hazard in past Watershed Analyses will have similar hazards. If the Road Sediment Reduction Plan cannot be developed in cooperation with other landowners within two years of issuance of the ITP, Tacoma will provide 100 percent of the funding needed to complete surveys of roads on or used to access Tacoma's lands, and will develop an annual road maintenance, improvement and abandonment plan for those roads. Upon completion of future Watershed Analyses, Tacoma will implement any additional prescriptions that may be approved.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-03C

MEASURE: Road Construction

Tacoma will continue to construct roads throughout all three zones in the Upper HCP Area (subject to compliance with other measures in this HCP) to facilitate watershed management, forestry activities and implementation of this HCP. Tacoma will implement prescriptions developed by Watershed Analysis specific to construction of new temporary or permanent roads across unstable landforms in the Upper HCP Area. Tacoma will cause no net increase in permanent road miles within the Natural Zone over the term of this HCP. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to protect water quality and fish habitat in the upper Green River watershed through proper road construction.

Rationale and Ecosystem Benefits

Watershed analysis includes an assessment of mass wasting hazards associated with forest management practices, including road building. The potential hazards and mechanisms that may trigger landslide activity vary by landform (Mass Wasting Map Unit), thus specific prescriptions for road construction are developed for each landform. Mass wasting assessments conducted as part of the Lester, upper Green/Sunday, and Howard Hanson/Smay Watershed Analyses have identified a relatively consistent suite of landforms that are considered to have a moderate to high mass wasting potential. These

landforms include earthflow toes, bodies and scarps; inner gorges; headwalls; glaciofluvial terrace escarpments, and steep undissected hillslopes in various geologic units (Plum Creek 1996; USFS 1996). The preferred alternative is to avoid road construction in these landforms. However, locating roads so that they do not cross unstable landforms may result in unacceptable increases in the total length of road constructed.

Draft and final prescriptions for WAUs in the upper Green River HCP Area generally require that a slope stability specialist review all proposed new roads on slump-earthflow toes, avalanche chutes, headwalls, escarpments along the Green River and areas prone to slumping along mainstem tributary canyons. In most cases, full bench construction techniques and end-hauling are required, natural drainage patterns must be maintained, road drainage must be directed away from the unstable landform where possible, and unless the geotechnical review indicates otherwise, stream crossings should be either hardened fords, bridges, or temporary, oversized culverts that are removed within three years of construction.

Upon issuance of the ITP, Tacoma will implement all draft and final mass wasting prescriptions specific to new road construction in WAUs where watershed analyses are approved or pending. In WAUs where assessments have not been completed within two years following issuance of the ITP, Tacoma will complete a slope stability analysis as described in HCM 3-01N. Tacoma will assume that all landforms identified as having a moderate to high mass wasting hazard in past Watershed Analyses will have similar hazards, and utilize the same prescriptions. To facilitate accurate field identification of landforms with moderate to high mass wasting potential, Tacoma employees responsible for harvest unit and new road layout will receive training in field identification of unstable lands. Tacoma will fund 100 percent of the cost required to ensure that roads are constructed in accordance with all applicable prescriptions derived from Watershed Analysis.

Roads will continue to be necessary in the Natural Zone to facilitate access for watershed management activities and to comply with Tacoma's requirements to allow access to adjacent landowner. Limiting roads in the Natural Zone to the current road density may require Tacoma to provide funds for permanently abandoning existing roads according to standards outlined in the Washington State Forest Practices Rules (Chapter 222-24-050 WAC). Tacoma will fund 100 percent of the costs of abandoning existing roads should such activities become necessary to offset construction of new roads.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-03D

MEASURE: Roads on Side Slopes Greater Than 60 Percent

When constructing roads on side slopes greater than 60 percent, Tacoma will use full bench construction with no side casting of excavated materials. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to protect water quality and fish habitat in the upper Green River watershed by restricting the methods of road construction used on steep slopes.

Rationale and Ecosystem Benefits

Studies of the relationship between forest roads and mass wasting in the Pacific Northwest indicate that inappropriate design, location and construction methods have historically been the primary cause of increased failure rates (Harr and Nichols 1993; Swanston and Swanson 1976). Road construction on steep slopes using cut-and-fill design increases the slope angle, redistributes weight, and may lead to the incorporation of organic materials into road fills, resulting in an increased risk of failure on otherwise stable sites. Full bench road construction on steep slopes has reportedly substantially reduced the incidence of road-related landslides (Sidle et al. 1985). Full bench road construction involves cutting a bench equal to the width of the road into the rock or soil and hauling excess material off-site to a stable storage location (Weaver and Hagans 1994).

Road fill failures were identified as one of the main causes of increased sediment delivery to channels in the Green River Watershed by a recent watershed analysis (USFS 1996). By utilizing only full bench construction techniques on steep slopes, Tacoma will minimize the incidence of future road fill failures, and thus reduce the delivery of sediment to stream channels. Reducing the amount of sediment delivered to stream channels is expected to reduce substrate embeddedness and the proportion of fine sediment in spawning gravel while increasing pool depths.

Full bench construction can cost four to seven times more than cut-and-fill methods (Weaver and Hagans 1994). Tacoma will fund 100 percent of the costs associated with implementing road construction standards beyond those required by Washington State Forest Practices Rules (WAC 222) on steep slopes.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-03E

MEASURE: Erosion Control

Tacoma will place mulch and/or grass seed on all road cuts and fills with slopes over 40 percent or near water crossings, as well as in all locations where there is the possibility of severe erosion or slumping above or below the road. All mainline, primary and secondary roads that Tacoma is responsible for maintaining in the HCP area will be surfaced with gravel. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to protect water quality and fish habitat in the upper Green River watershed by implementing proper erosion control measures.

Rationale and Ecosystem Benefits

The level of traffic and composition of road surfaces are major determinants of the amount of sediment produced from forest roads. In general, unpaved dirt roads produce almost twice as much sediment per unit area than comparable roads surfaced with a two to six inch layer of gravel (WFPB 1997). Tacoma will work cooperatively with other landowners in the upper Green River HCP Area to ensure that gravel surfacing is maintained on all mainline, primary and secondary haul roads.

Watershed analyses in Washington and Oregon have shown that unvegetated road cutslopes and fillslopes within 200 feet of the stream channel supply fine sediment to stream channels even during periods of light traffic use (Madsen 1998; Veldhuisen 1998). The rate of sediment delivery is a function of slope steepness (Ketcheson and Megahan 1996). Mulch and grass seeding of cut-and-fill slopes may reduce surface erosion by up to 70 percent (Megahan 1987).

By mulching or seeding exposed road cuts and fills in steep terrain, Tacoma will reduce the amount of fine sediment delivered to stream channels via overland flow or drainage ditches. Reducing the amount of sediment delivered to stream channels is expected to reduce substrate embeddedness and the proportion of fine sediment in spawning gravel, while increasing pool depths. Tacoma will fund 100 percent of the costs required to mulch or establish vegetative cover on road cut-and-fill slopes within the Upper HCP Area.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-03F

MEASURE: Stream Crossings

In the limited instance when constructing roads across streams and through riparian buffers is necessary, Tacoma will: 1) minimize right-of way clearing; 2) cross streams and riparian corridors at right angles (wherever possible); 3) minimize disturbance to the natural flow of streams; 4) minimize side casting of excavated materials; and 5) provide for upstream and downstream passage of fish if the stream reaches are fish-bearing. Culvert design criteria to support upstream and downstream passage of salmonids will be developed in coordination with WDFW, USFWS, and NMFS. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to protect water quality and fish habitat by properly designing, constructing, and maintaining stream crossings.

Rationale and Ecosystem Benefits

Where roads cross stream channels, provisions must be made to pass flow under the road while maintaining up and downstream fish passage. Drainage structures should be large enough to pass flood flows, and should be installed at a grade equal to or slightly lower than the original stream channel gradient so that normal velocity is maintained and so fish do not have to jump up into the structure. Roads should cross the channels at right angles if possible, and culverts should be aligned with the stream channel so that the inlet will not plug, and flow from the outlet is not deflected into the channel bank (Weaver and Hagans 1994).

Stream crossing sites are also the most frequent source of erosion and sedimentation (Rothwell 1983). Because stream crossings are the location where roads come in closest contact with flowing water, it is important to minimize disturbance of riparian buffers, to construct roads using as little fill material as possible, and to dispose of excavated materials outside of the floodplain (Weaver and Hagans 1994). Vegetation removal should be limited, and exposed slopes should be quickly replanted. Fills should be compacted and armored, with excavated material disposed of off-site.

When constructing or reconstructing roads through riparian buffers, Tacoma will minimize right-of-way clearing, cross streams at right angles, and minimize side casting of excavated materials. Stream crossing structures will be designed so that up stream and downstream fish passage is maintained on fish bearing streams. Application of these

measures will reduce the amount of soil disturbance and deposition of loose fill material within the floodplain, thus minimizing sediment-related impacts to fish habitat. Tacoma will provide 100 percent additional design and construction costs required to meet these high road standards.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-03G

MEASURE: Road Closures

Where Tacoma has control over road use, the City will maintain locked gates to restrict use of roads in the Upper HCP Area by the general public, except where U. S. Forest Service or Washington State Department of Natural Resources policy requires that roads remain open. Tacoma will also discontinue heavy truck traffic under its control (e.g., log hauling) when there is a potential for **excessive** ~~extraordinary~~ damage to the road or **water quality impacts that would adversely affect fish.** ~~an impact on water quality.~~ **For purposes of this measure, excessive damage means damage beyond normal wear to the road surface.** Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to protect water quality and fish habitat by restricting vehicle traffic on Tacoma roads in the upper Green River watershed.

Rationale and Ecosystem Benefits

The amount of sediment generated from road tread surfaces is largely a function of traffic (Reid and Dunne 1984). Increased sediment concentrations associated with heavy truck traffic have been documented throughout western Washington (Bilby et al. 1989; Reid and Dunne 1984; Wooldridge 1979). Sediment produced by vehicle traffic on forest roads is predominantly silt and clay size material that is rapidly flushed through the system at even moderate discharges (Bilby et al. 1989; Bilby 1985). Because of the small size of sediment generated by road use, it rarely deposits or intrudes into the substrate except in the smallest streams (Bilby et al. 1989) or during periods of low flow (Bilby 1985). However, fine sediment generated by road use may increase turbidity, which can decrease primary productivity (Gregory et al. 1987), interfere with the ability of juvenile salmonids to capture prey (Lloyd et al. 1987), and detrimentally impact water quality (EPA 1993).

By restricting access to the Upper HCP Area and suspending log hauling when there is a potential for extraordinary water quality impacts, Tacoma will minimize the impact of the production of sediment caused by road traffic. Road use restrictions are expected to

prevent excessive turbidity from impacting aquatic species or water quality. Incidental benefits to terrestrial wildlife that may be disturbed by frequent vehicle traffic may also occur. Tacoma will fund 100 percent of the costs required to construct and maintain locked gates in the Upper HCP Area.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-03H

MEASURE: Roadside Vegetation

Tacoma will maintain low-growing vegetation along roadsides to stabilize soils and minimize erosion. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to protect water quality and fish habitat by reducing surface erosion from disturbed soils.

Rationale and Ecosystem Benefits

Surface protection of road cut-and-fill slopes can reduce erosion during storms and prevent or restrain the downslope movement of soil slumps (EPA 1993). Swift (1986) found that vegetated cut-and-fill slopes were more effective than mulched fill at reducing the downslope movement of soil from road cut-and-fill surfaces, and could reduce sediment production by over 90 percent.

Maintaining low-growing vegetation along roadsides in the Upper HCP Area will minimize the production of sediment from road cut-and-fill slopes and reduce the likelihood of sediment-related impacts to fish habitat and water quality. Tacoma will fund 100 percent of the costs required to maintain vegetation along roadsides within the Upper HCP Area.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-03I

MEASURE: Road Abandonment

Tacoma will abandon roads in the Upper HCP Area that are no longer needed for adjacent landowners to access their property, watershed management, forestry operations, or implementation of this HCP. Within two years of issuance of the ITP, Tacoma will prepare and prioritize plans to abandon unnecessary existing roads. Within five years of issuance of the ITP, Tacoma will complete the abandonment of the unnecessary existing roads. New roads constructed in the Conservation and Commercial Zones that are not needed for the above purposes will be abandoned within two years after their use is complete. Roads will be abandoned by: 1) removal

of culverts, fills, water blocks and unstable landings; 2) stabilization of ditch lines and cut banks to a slope of 1.5:1; 3) crowning of road surfaces and placement of water bars every 200 feet; 4) placement of biomatting on steep erodible slopes; 5) re-vegetation of disturbed soils and biomatted areas with grass **and appropriate tree** seed**lings**; and 6) placement of berms or walls of stumps, rootwads, or logs at former entrances to roads. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to protect water quality and fish habitat by properly abandoning roads that are no longer necessary in the upper Green River watershed.

Rationale and Ecosystem Benefits

There are many reasons for abandoning a forest road, including improving fish and wildlife habitat, excessive maintenance costs, lack of future need due to improved harvest methods, or continuing water quality problems (Weaver and Hagans 1994). In the past, roads were closed by simply prohibiting access. However, sediment yields from closed roads often increase, as severe gullies may form on poorly drained road tread surfaces, and unmaintained drainage structures frequently become plugged and fail catastrophically. Planned abandonment is an inexpensive technique that can prevent future damage to the active road system as well as to aquatic resources by removing potentially unstable drainage structures and fills, restoring the natural drainage network, and revegetating disturbed soils.

By abandoning roads within the HCP area that are no longer needed for watershed management, forestry operations or implementation of this HCP, Tacoma will minimize the potential for future mass wasting and sediment production from unmaintained roads within the Upper HCP Area. In addition, the total length of the road network may decrease, reducing annual sediment inputs as well as the need for expensive long-term maintenance. Tacoma will provide 100 percent of the funding necessary to permanently abandon unneeded roads.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-03J

MEASURE: Culvert Improvements

Within one year of issuance of the ITP, Tacoma will inventory all roads on Tacoma lands to identify artificial barriers that create blockages to fish passage. Within two years of issuance of the ITP, Tacoma (in coordination with other affected landowners, MIT and WDFW) will prepare and prioritize plans for eliminating artificial blockages on roads they are responsible for maintaining. Within five years of issuance of the ITP,

Tacoma will complete the elimination of artificial blockages on Tacoma Lands in the HCP Area as requested and approved by the Services. New culverts, if needed, will be designed and constructed to pass 100-year flood flows and allow up and downstream fish passage. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to increase fish utilization of habitats in the upper Green River watershed by removing man-made blockages to upstream and downstream movement.

Rationale and Ecosystem Benefits

A single poorly installed culvert can eliminate the fish population of an entire stream system (Murphy 1995). Stream crossing conditions that block fish passage include: excessive water velocity, insufficient flow depth, absence of pools that provide resting or jumping space at culvert outlets, and culvert outlets that are too high above the streambed (Furniss et al. 1991). Undersized culverts are likely to become blocked or fail during major storm events (Veldhuisen 1997).

Adult salmon access to the upper watershed is currently precluded; however, the HCP contains provisions to trap adult fish at the Headworks and release them above HHD. Restoring passage at culvert blockages identified in the Upper HCP Area will ensure that anadromous fish have access to habitat within the upper watershed, and will allow unimpeded migration and genetic transfer for resident fish populations.

By completing a systematic inventory of all roads on their lands Tacoma will be able to identify culverts that create blockages to fish passage.

Artificial blockages will be prioritized for treatment as follows:

- barriers to habitat known to have historically been utilized by listed species will be treated first;
- habitat that could be used by anadromous fish as spawning or overwintering areas;
- for resident fish, population risk factors will be considered, such as:
  - > blockages that prevent the ability of populations to recolonize original habitats
  - > blockages that have fragmented existing populations, thereby contributing to poor genetic integrity.

Under each category, the length of habitat upstream of the blockage and the location of the blockage relative to planned management activities and major road maintenance projects will also be considered. Within two years, plans will be completed for re-establishing upstream and downstream passage at sites where such action is deemed necessary by the Services. Artificial blockages on Tacoma lands will be treated as requested by the Services within five years of issuance of the ITP.

Road Sediment Reduction Plans prepared to as part of the watershed analysis prescription addressing existing hazards (Lester Watershed Analysis) must include a methodology for inspecting stream crossings in landforms with a moderate to high mass wasting potential following major storm events. Post-storm inspections will ensure that blockages resulting from high return interval events following the initial inventory are identified and corrected in a timely manner. Stream crossing culverts replaced during the term of the ITP will meet all criteria required to maintain fish passage.

Tacoma will provide 100 percent of the funding required to conduct the systematic road inventory and repair all road-related passage barriers.

5.3.4 Habitat Conservation Measure: HCM 3-04 Species-Specific Management Measures

SPECIES-SPECIFIC MANAGEMENT MEASURES

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04A

MEASURE: Grizzly Bear Den Site Protection

Tacoma will conduct no timber felling, yarding, road construction, or aerial application of pesticides within 1 mile of any known active grizzly bear den from 1 October through 31 May. At other times of year, Tacoma will contact the USFWS and WDFW prior to any timber harvest or road construction within 3 miles of a known grizzly bear den, and the three parties will discuss possible steps that can be taken to minimize impacts to potential denning habitat. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to minimize human disturbance of denning grizzly bears in the upper Green River watershed.

Rationale and Ecosystem Benefits

The HCP Area lies outside the North Cascades Recovery Zone for the grizzly (USFWS 1993), but it is connected to the recovery zone by contiguous habitat. Recent sightings of grizzly bears have been made in the vicinity of the Upper HCP Area outside the recovery zone (Almack 1993, cited in USACE 1996), suggesting that occasional use of the Upper HCP Area may already be occurring. If grizzly bear populations increase in the recovery zone as a result of recovery efforts, individual animals could range into the Upper HCP Area.

Grizzly bears are particularly sensitive to the presence of humans, and will avoid areas of human activity (USFWS 1997). The denning season, which begins in the early fall and extends through spring, is a particularly vulnerable time of year for the grizzly bear. Late initiation of denning or early abandonment of a den as a result of human disturbance can force a bear out of hibernation at a time of year when food is scarce and metabolic demands are high. Agitation of bears within dens, even if it does not lead to abandonment, can impact bears by increasing metabolic demands during hibernation. Such impacts can be avoided by restricting human activity around active dens. The den site protection measures are consistent with current Washington Forest Practices Rules and Regulations for the protection of critical wildlife habitats (WAC 222-16-080[1][c]), and are designed to avoid incidental take of grizzly bears during the denning season.

While grizzly bears seldom reuse specific den sites (Interagency Grizzly Bear Committee 1987), they often den within 0.3 to 3.1 miles of previous dens, and are known to den repeatedly within a radius as small as 1.7 miles. Because the HCP Area is not typical grizzly bear habitat, it is impossible to identify specific activities that should or should not take place in the proximity of grizzly bear dens that might occur in the future. Tacoma will, however, contact the USFWS prior to conducting activities that could alter suitable habitat within 3 miles of known den sites, so that appropriate precautions can be identified.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04B

MEASURE: Grizzly Bear Sightings

Tacoma will suspend all forest management and road construction activities under its control in the Upper HCP Area within 1 mile of confirmed grizzly bear sightings for 21 days following the last confirmed sighting. Confirmation of grizzly bear sightings will be made by WDFW, USFWS, or TPU personnel trained in the identification of grizzly bears according to HCM 3-01K. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to minimize human displacement of grizzly bears from the upper Green River watershed.

Rationale and Ecosystem Benefits

As noted above, grizzly bears are particularly sensitive to the presence of humans. Human activity during summer months can cause grizzly bears to avoid specific areas, some of which may be important seasonal feeding areas. While it may be feasible to suspend human activities around fixed points, such as dens that grizzly bear will occupy for extended periods of time, it is not feasible to suspend all activities over broad areas during the summer when grizzly bears are active. Rather, Tacoma will implement restrictions around specific areas where grizzly bears are sighted, and the City will continue restrictions for periods of time sufficient to allow the animals to move unimpeded by the presence of humans.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04C

MEASURE: Grizzly Bears and Roads

Tacoma will not construct roads across non-forested blueberry fields (*Vaccinium* spp.) and black huckleberry fields (*Vaccinium membranaceum*), meadows, avalanche chutes, or DNR Type A or B wetlands in the upper Green River HCP Area.

Objective

The objective of this measure is to minimize the disturbance and/or destruction of key foraging habitats for grizzly bears.

Rationale and Ecosystem Benefits

Grizzly bears are known to avoid roads, particularly those with frequent or regular human use (USFWS 1997). Roads are a necessary component of a managed watershed, however, and cannot be excluded altogether from the Upper HCP Area. To minimize the potential for impacting grizzly bear activities with the presence of roads, Tacoma will construct no roads through areas of particular importance to grizzly bears. Berry fields, meadows, avalanche chutes, and wetlands make up a relatively small percentage of the Upper HCP Area, but they are important foraging areas for grizzly bears. Avoiding the construction of roads through these areas will substantially reduce the potential for road-related impacts to bears.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04D

MEASURE: Grizzly Bear Visual Screening

If grizzly bear presence is documented in the Green River Watershed, Tacoma will retain visual screens along the margins of preferred habitats (e.g., meadows, riparian areas, and berry fields) or along roads that are within 1 mile and in direct line of sight of preferred habitats. Visual screens at a minimum will consist of non-merchantable trees and shrubs, where they are available, which can obscure 90 percent of a grizzly bear standing on all four feet at a distance of 100 feet. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to minimize human displacement of grizzly bears from important foraging habitats in the upper Green River watershed.

Rationale and Ecosystem Benefits

As noted above, meadows, wetlands and berry fields are important feeding areas for grizzly bears, and human activity in or near these areas can cause bears to avoid them (Interagency Grizzly Bear Committee 1987). Disturbance-related impacts can be avoided by providing visual screening between roads and key feeding areas. This measure will provide that type of screening. Given that grizzly bears are currently quite rare in the Upper HCP Area, this measure will not take effect unless the presence of bears is documented. However, current management practices and native vegetative conditions in the Upper HCP Area are such that visual screening will exist along most roads throughout the term of the HCP, regardless of grizzly bear presence. This measure is simply an added layer of protection in the event that grizzly bear numbers increase in the future.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04E

MEASURE: Grizzly Bears and Trash

Tacoma will continue to take measures to prevent the dumping of putrescent trash that could attract grizzly bears. This will include: 1) restricting general public access to the upper Green River HCP Area below the town of Lester; 2) prohibiting City employees and other authorized watershed users from dumping or disposing of trash in the Upper HCP Area; and 3) cleaning up any newly discovered trash disposal sites in the Upper HCP Area as soon as possible. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to prevent grizzly bears in the upper Green River watershed from habituating to the scent and/or presence of humans.

Rationale and Ecosystem Benefits

As omnivores, bears are well known for their tendency to feed at human garbage dumps (Interagency Grizzly Bear Committee 1987). Grizzly bear use of garbage dumps is undesirable because it can cause bears to become habituated to the scent and presence of humans, and ultimately lead to interactions that necessitate the removal or destruction of individual bears. Conflicts can be avoided if garbage is controlled and disposed of properly.

The Upper HCP Area, as a municipal watershed, is closed to the general public. Permitted users in the Upper HCP Area are required to comply with stringent trash and garbage control policies (TPU 1993). Continued adherence to these policies, as described in this measure, will ensure there are no problem bear situations in the future.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04F

MEASURE: Grizzly Bears and Firearms

Tacoma will prohibit firearms within the vehicles of contractors working for Tacoma in the Upper HCP Area, except when being used for security purposes, for WDFW-approved hunts, or in conjunction with Native American Tribal hunting. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to prevent the unauthorized shooting of a grizzly bear in the upper Green River Watershed.

Rationale and Ecosystem Benefits

Unauthorized shooting of grizzly bears is a potential problem whenever this formidable creature comes into contact with humans. Shootings can be minimized by limiting the use of firearms by humans working in grizzly bear country. Certain individuals working in the Upper HCP Area (such as watershed patrols) may need to carry firearms, but all other persons under the jurisdiction of Tacoma will be prohibited from carrying firearms while in the area.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04G

MEASURE: Gray Wolf Den Site Protection

Tacoma will conduct no timber felling, yarding, road construction, blasting, or aerial application of pesticides within 1 mile of any known active gray wolf den from 15 March through 15 July. Tacoma will conduct no timber felling, yarding, road construction, blasting or aerial application of pesticides within 0.25 mile of any known active gray wolf "first" rendezvous sites from 15 May through 15 July. A "first" rendezvous site is the first such site used by a wolf pack after leaving the whelping den in the spring. Tacoma will contact the USFWS and WDFW prior to conducting harvest activities outside the denning season within 0.25 mile of a known den site to minimize management impacts on future den site use. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to protect denning gray wolves in the upper Green River watershed from human disturbance.

Rationale and Ecosystem Benefits

The gray wolf is extremely rare in Washington, but sightings have been made in the Cascade Mountains as far south as Randle, Washington (USFS 1998), and the species could use the Upper HCP Area on an occasional basis. Gray wolves use dens for six to 10 weeks in the spring and early summer if they are rearing pups. Once the pups are whelped, they are typically moved by the adults to a rendezvous site where they stay while the adults are hunting. They are sensitive to human presence during this entire time, and may abandon a den or rendezvous site if disturbed (USFWS 1987). The den site protection measures are consistent with current Washington Forest Practices Rules and Regulations for the protection of critical wildlife habitats (WAC 222-16-080[1][b]), and are generally considered adequate to avoid take of gray wolves during the denning season. Rendezvous site protection measures are added to this HCP to provide an additional disturbance buffer during that phase of wolf reproduction.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04H

MEASURE: Pacific Fisher Den Site Protection

Tacoma will conduct no timber felling, yarding, road construction, blasting, or aerial application of pesticides within 0.5 mile of any known active Pacific fisher den between 1 February and 31 July. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to protect denning Pacific fishers in the upper Green river watershed from human disturbance.

Rationale and Ecosystem Benefits

The fisher is rare throughout the western United States. Populations were severely depressed by trapping in the last century, and they have been slow to recover because of naturally low reproductive rates and a general loss of habitat to logging of old coniferous forest (Powell and Zielinski 1994). Management of the Natural and Conservation zones and riparian corridors in the Commercial Zone of the Upper HCP Area will, over time, create suitable denning habitat for the fisher (mature forest with large snags and logs), and the potential for fisher occurrence in the area will increase. Den site protection measures will be necessary in the HCP Area to ensure that human activities do not prevent the use of otherwise suitable habitat. While human activity has not been demonstrated as a significant factor in determining fisher use of an area, the importance of successful reproduction to the overall conservation of the species warrants measures such as Pacific fisher den site protection to limit human activity around established dens.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04I

MEASURE: California Wolverine Den Site Protection

Tacoma will conduct no timber felling, yarding, road construction, blasting, or aerial application of pesticides within 0.5 mile of any known active wolverine den between 1 October and 31 May. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to protect denning California wolverines in the upper Green River watershed from human disturbance.

Rationale and Ecosystem Benefits

The wolverine is a species of alpine and subalpine forests (Banci 1994), and may occur on an occasional basis in the upper reaches of the Green River watershed (USFS 1996). Tacoma lands in the Green River watershed are concentrated along the river (at the valley bottom), where wolverines are unlikely to occur, but den site protection measures are included in this HCP in the event that Tacoma acquires lands at higher elevations in the future. The wolverine is generally considered a wilderness species that avoids human contact, but recorded instances of wolverines in close association with humans raise

questions as to whether wolverines actually avoid humans or they simply prefer habitats that currently are not heavily exploited by humans (Banci 1994). Given the uncertainty as to wolverine sensitivity to human presence, it is considered prudent to include den site protection measures in this HCP.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04J

MEASURE: Canada Lynx Den Site Protection

Tacoma will conduct no timber felling, yarding, road construction, blasting or aerial application of pesticides within 0.25 mile of any known active Canada lynx den from 1 May through 31 July. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to protect denning Canada lynx in the upper Green River watershed from human disturbance.

Rationale and Ecosystem Benefits

The Canada lynx inhabits the boreal forests of Canada and Alaska, and extends south into the lower 48 states in the isolated areas where boreal forest conditions exist (Koehler and Aubry 1994). In Washington, the distribution of the lynx is largely restricted to high-elevation pine and spruce forests of eastern Washington (Johnson and Cassidy 1997), but rare sightings have been made in the Green River watershed (USFS 1996). The Upper HCP Area does not contain habitat typically considered suitable for the lynx, and it is not likely to in the future under the proposed management. Nevertheless, den site protection measures are included in this HCP to ensure that any dens that are documented in the area receive adequate protection. This measure is based on recommendations from the WDFW contained within the Washington DNR Lynx Habitat Management Plan (Washington DNR 1996).

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04K

MEASURE: Seasonal Protection of Peregrine Falcon Nests

Tacoma will conduct no timber felling, yarding, road construction, or aerial application of pesticides within 0.5 mile or blasting within 1 mile of any known active peregrine falcon nest from 1 March through 31 July. If an active nest fails or is otherwise found to be unoccupied after 1 June, seasonal protection will be removed for that year. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to protect peregrine falcon nest sites from human alteration and destruction.

Rationale and Ecosystem Benefits

Peregrine falcons nest on high cliff ledges or man-made structures (Cade et al. 1996), and hunt over large wetlands or marine shorelines (USFWS 1982). A number of peregrine falcon nest sites are known to occur in the Cascade Mountains, but currently there are none in the Green River watershed. The potential exists for nesting in the future because of the presence of several suitable cliff ledges and recent sightings of peregrine falcons flying through the area (USFS 1996). Like many large birds of prey, peregrine falcons are sensitive to human activity around nests (USFWS 1982). The disturbance avoidance measures included in the seasonal protection of peregrine falcon nests are consistent with current Washington Forest Practices Rules and Regulations for the protection of critical wildlife habitats (WAC 222-16-080[1][f]), and are generally considered adequate to avoid take of peregrine falcons during the nesting season.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04L

MEASURE: Long-Term Protection of Peregrine Falcon Nest Sites

Tacoma will conduct no timber felling or other habitat alteration within 100 feet of any known peregrine falcon nest site and all potential nest cliffs greater than 75 feet in height (measured horizontally) in the Upper HCP Area. During timber harvesting within 660 feet of known peregrine falcon nest sites, Tacoma will retain all "super dominant" trees (i.e., those dominant trees that are significantly larger and taller than the remaining trees in the stand, and extend above the dominant/codominant canopy). Retained super dominant trees will count toward meeting the snag and green recruitment tree requirements of Measure HCM 3-01G. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to protect nesting peregrine falcons in the upper Green River watershed from human disturbance.

Rationale and Ecosystem Benefits

As noted in seasonal protection of peregrine falcon nests, peregrine falcons currently do not nest in the Green River watershed, but the potential exists for nesting in the future. One cliff with suitable nesting ledges exists within the Upper HCP Area, and a buffer of

100 feet will be placed around the cliff to ensure that future timber harvesting activity will not remove any visual screening that may contribute to the suitability of the site. Beyond the visual screen, the retention of large super dominant trees up to 660 feet from nests will ensure a source of potential perch trees for adult peregrines during the nesting season. While there are currently no other areas considered suitable for nesting within the HCP Area, this measure will also provide for 100-foot buffers should peregrines establish nests in other atypical locations.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04M

MEASURE: Seasonal Protection of Bald Eagle Nests and Communal Winter Night Roosts

Tacoma will conduct no timber felling, yarding, road construction, or other habitat alteration within 0.25 mile (or within the direct line of sight, up to a minimum of 0.5 mile), no aerial application of pesticides within 0.5 mile and no blasting within 1 mile of any known active bald eagle nest from 1 January through 31 August and any know bald eagle communal winter night roost from 15 November through 15 March. Activity restriction around nests will apply 24 hours per day; activity restrictions around roosts will apply from one hour before sunset until one hour after sunrise. If eaglets have fledged from a nest prior to 31 August, seasonal protection will be removed for that year. If an active nest fails or is otherwise found to be unoccupied after 1 May, seasonal protection will be removed for that year. If wintering eagles fail to use a communal night roost in a given year, or vacate a roost prior to 15 March, seasonal protection will be removed for that year. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to protect nesting and roosting bald eagles in the upper Green River watershed from human disturbance.

Rationale and Ecosystem Benefits

Bald eagles are relatively common in western Washington (Smith et al. 1997), where they nest near large lakes, rivers and marine waters and spend the winter along rivers with anadromous fish runs (USFWS 1986). They do not currently nest or winter in the Upper HCP Area, but they are often seen in the area of Howard Hanson Reservoir. They could begin nesting or wintering in the area in the future if populations of fish and/or waterfowl increase. Winter feeding and roosting, if it occurs, will likely be in the Natural or Conservation zones where late-seral forest conditions will develop along larger water bodies. Additional measures to protect bald eagle winter use of the Upper HCP Area are

not necessary, particularly since it would occur during a season of relatively little human activity in the surrounding forest. Nesting, on the other hand, could occur in any of the zones where large trees are present, and would come at a time of year when potentially disturbing activities such as timber harvesting are taking place. Nest site protection measures are therefore included in this HCP to limit human disturbance of active bald eagle nests. These measures are generally consistent with current Washington Forest Practices Rules and Regulations for the protection of critical wildlife habitats (WAC 222-16-080[1][a]), and are designed to avoid incidental take of bald eagles during the nesting season.

Bald eagles also rely heavily on the use of communal winter night roosts in western Washington (Stalmaster 1987). These are typically areas of mature coniferous or deciduous forest with favorable microclimates and proximity to winter feeding areas. The specific requirements of communal roosts are not well understood, so emphasis is placed on protecting areas of known use. While no winter roosts are currently known to occur in the Upper HCP Area, there exists a potential for them to occur in the future as a result of increases in both bald eagle populations and fish populations in the Green River. This measure and the following measure (HCM 3-04N) will allow for the protection of roosts if they are established. Buffer distances are those recommended in the Recovery Plan for the Pacific Bald Eagle (USFWS 1986).

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04N

MEASURE: Long-term Protection of Bald Eagle Nests and Communal Winter Night Roosts

Tacoma will conduct no timber felling or other habitat alteration within ~~330~~ **400** feet of any known bald eagle nest or communal winter night roost in the Upper HCP Area. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to protect bald eagle nest and roost sites in the upper Green River watershed from human disturbance.

Rationale and Ecosystem Benefits

Adult bald eagles mate for life and typically return to the same nesting area year after year (Stalmaster 1987). They will use the same nest for several years, or alternate between two or more nests in the same general area. This behavior is not surprising, given the amount of energy required to construct a nest and the difficulty finding trees

with the appropriate size, structure, and location. Protection of existing nests in the non-nesting season is therefore considered important to the overall conservation of the species. The long-term protection of bald eagle nests will ensure that any bald eagle nests in the Upper HCP Area will be protected from habitat alteration during timber harvesting or other potentially disruptive activities.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04O

MEASURE: Seasonal Protection of Northern Spotted Owl Nests

Tacoma will conduct no timber felling, yarding, road construction, or aerial application of pesticides within 0.25 mile (1,320 feet) or blasting within 1 mile (5,280 feet) of the activity center of any known northern spotted owl pair from 1 March through 30 June, unless the spotted owls inhabiting the activity center have been found, through USFWS protocol surveys, to be non-reproductive or to have failed to successfully reproduce during a given year. Determinations as to the reproductive status of a given spotted owl pair will be made no earlier than 15 May of the year in question. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to protect nesting northern spotted owls in the upper Green River watershed from human disturbance.

Rationale and Ecosystem Benefits

The Green River watershed has been surveyed extensively for spotted owls since the federal listing of the species as threatened in 1990. There is one spotted owl activity center on Tacoma lands within the Upper HCP Area, nine activity centers within 0.7 mile of the Upper HCP Area and six more within 1.8 miles of the Upper HCP Area. Timber harvesting activities by Tacoma could influence the amount of habitat available to the spotted owls inhabiting these 16 activity centers and alter the behavior of some of the spotted owls at the activity centers closest to Tacoma lands.

Any short-term decreases in habitat for spotted owls that may result from timber harvesting in the Upper HCP Area will be more than offset in the mid- and long-terms by the development and maintenance of suitable nesting, roosting and foraging habitat throughout most of the Natural and Conservation zones. Roughly 78 percent of Tacoma's land is forested, and two-thirds of this (7,812 acres) is within the Natural and Conservation zones that will be managed specifically to promote and maintain late-seral forest habitat conditions for spotted owls. Extended harvest rotations (70 years),

extensive no-harvest riparian buffers, and increased rates of snag/green tree retention in the Commercial Zone will result in a significant portion of that zone functioning as habitat for spotted owls as well. Additional measures specific to the creation and maintenance of spotted owl habitat at the landscape level are not necessary.

Timber harvesting and related activities also have the potential to affect spotted owls by disturbing actively nesting pairs and causing them to interrupt or abandon nesting attempts. This situation will be avoided by implementing seasonal protection of the northern spotted owl which will require buffers of 0.25 mile around all known activity centers during the nesting season until it can be determined whether spotted owls are nesting. If nesting owls are present, protection will continue through the fledging and dispersal period for the young birds.

The *Protocol for Surveying Proposed Management Activities that May Impact Northern Spotted Owls* (USFWS 1992) specifies that determination of nesting status in a given year must be made prior to 1 June, and can be made as early as 16 April if the appropriate behaviors are observed. As a margin of certainty, Tacoma will conclude no determinations prior to 15 May. All determinations will be made according to the protocol developed by the USFWS (1992).

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04P

MEASURE: Long-Term Protection of Northern Spotted Owl Nests

Tacoma will conduct no timber felling or other habitat alteration within 660 feet of the activity center of any known northern spotted owl pair or resident single located in the Upper HCP Area, until it has been found, through USFWS protocol surveys, that a given activity center has been unoccupied for at least 36 months. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to protect northern spotted owl nests in the upper Green River watershed from human alteration and destruction.

Rationale and Ecosystem Benefits

As noted in the seasonal protection of the northern spotted owl, potential nesting habitat for spotted owls will be created and maintained with no even-aged harvesting on over 52 percent of the Upper HCP Area. Management of the Commercial Zone (approximately 20 percent of the Upper HCP Area) will emphasize commercial timber production, but

extended rotations (70 years), wide no-harvest riparian buffers, and snag/green tree retention measures will create the potential for spotted owl nesting in this zone as well. It is the intention of this HCP to promote spotted owl nesting in the Natural and Conservation zones, while minimizing the impacts to nesting owls in the Commercial Zone. The long-term protection of northern spotted owl nests will minimize the effects of timber harvesting near nest sites in the Commercial Zone by retaining approximately 31 acres of forested buffer around nest sites until they are abandoned. It is not expected that 31 acres will be sufficient habitat to support long-term nesting if the adjacent habitat is harvested, but when combined with the high overall amount of habitat throughout the Upper HCP Area, it will minimize direct impacts to nesting spotted owls and allow for transition of displaced owls to unoccupied habitat elsewhere in the area. Tacoma will not monitor all known spotted owl activity centers in all years, but Tacoma will monitor known activity centers according to USFWS (1992) protocol prior to any determinations of status change.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04Q

MEASURE: Seasonal Protection of Northern Goshawk Nests

Tacoma will conduct no timber felling, yarding or road construction within 0.25 mile, no aerial application of pesticides within 0.5 mile, and no blasting within 1 mile of any known active northern goshawk nest from 1 March through 31 August. If an active nest fails or is otherwise found to be unoccupied after 1 June, seasonal protection will be removed for that year. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to protect nesting northern goshawks in the upper Green River watershed from human disturbance.

Rationale and Ecosystem Benefits

The Green River watershed, including the Upper HCP Area, contains several thousand acres of forest habitat capable of supporting nesting and hunting by northern goshawks. Given the number of recent sightings in the watershed (USFS 1996), it is likely they occur in the Upper HCP Area. Management under the HCP will result in increases in suitable habitat for goshawks in all three zones, so there is an even higher likelihood that nesting will occur in the future. Goshawks will continue to use forest habitat in all three management zones of the Upper HCP Area under the proposed management because of the high density of mid- and late-seral forest that will occur, even in the Commercial Zone. Even-aged harvests (i.e., clearcuts) will not preclude the presence of goshawks if

the overall density of forested habitat is adequate, but harvesting activities could displace goshawks if they are conducted too close to active goshawk nests. To minimize impacts to nesting goshawks, Tacoma will implement the seasonal buffers described in the seasonal protection of northern goshawk nests.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04R

MEASURE: Long-Term Protection of Northern Goshawk Nests

Tacoma will conduct no timber felling or other habitat alteration within 660 feet of any known active northern goshawk nest in the Upper HCP Area, unless it has been determined that the nest has been unoccupied for at least eight consecutive years. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to protect northern goshawk nests in the upper Green River watershed from human alteration and destruction.

Rationale and Ecosystem Benefits

Goshawks will nest and hunt in managed forest landscapes if there is a sufficient density of suitable habitat (Reynolds et al. 1992). They are also known to nest in relatively young forest (≥ 40 years old) (Bosakowski and Vaughn 1996) if it contains at least a few trees of sufficient size to support nests. The Natural Zone will be free of timber harvesting, and should provide nesting opportunities for goshawks throughout the term of the HCP. Timber harvesting in the Conservation Zone will be uneven-aged and infrequent, and should not lead to nest site abandonment by goshawks if the area immediately surrounding the nest is protected. Timber harvesting in the Commercial Zone, while it will be even-aged, will involve small units and infrequent harvest entries. Again, long-term presence of nesting goshawks may be possible if the habitat immediately around nest trees is maintained. This habitat conservation measure will provide for long-term protection of nest sites, and should help ensure the continued presence of goshawks in the Upper HCP Area.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04S

MEASURE: Pileated Woodpecker Nest, Roost, and Foraging Trees

Tacoma will give preference to leaving green recruitment trees with visible signs of pileated woodpecker nesting, roosting, and/or foraging when selecting snags and trees to meet other HCMs. Persons authorized to select snags and green recruitment trees

will be instructed in how to identify signs of pileated woodpecker use. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to protect and enhance habitat for the pileated woodpecker in the upper Green River watershed.

Rationale and Ecosystem Benefits

Pileated woodpeckers are common in western Washington, but their numbers are probably reduced from historic levels as a result of habitat loss. They are particularly susceptible to conventional forest practices because of their need for large dead trees (snags) for foraging, nesting and roosting (Bull and Jackson 1995). Snags are typically removed during commercial timber harvesting to satisfy concerns for worker safety and fire prevention. Large snags are hard to replace in subsequent managed stands because most even-aged rotations are not long enough to grow trees of the size required by pileated woodpeckers. A number of measures in this HCP will act to avoid the effects of conventional forestland management and maintain habitat for pileated woodpeckers. Specifically, the retention of all existing forest habitat in the Natural Zone, the management for late-seral conditions in the Conservation Zone, the maintenance of wide no-harvest buffers on fish-bearing streams and smaller no-harvest buffers on all other streams, and the retention of large numbers of snags and residual green recruitment trees in conjunction with all timber harvesting will provide large trees and snags across most of the Upper HCP Area. The pileated woodpecker nest, roost, and forage tree habitat conservation plan is intended to focus on green recruitment trees so that the trees selected for retention at the time of commercial timber harvesting provide the maximum benefit to pileated woodpeckers. Persons responsible for selecting and marking trees to be left will be trained in the identification of pileated use so that these features can be preserved in the Upper HCP Area.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04T

MEASURE: Vaux's Swift Nest and Roost Trees

Tacoma will give preference to leaving green recruitment trees with visible signs of current Vaux's swift nesting and/or roosting and those with the potential for future use when selecting snags and trees to meet other HCMs. Tacoma will attempt to leave other green recruitment trees clumped around trees with signs of Vaux's swift use to protect the swift trees from windthrow and moderate microclimates at potential roosts. Persons authorized to select snags and green recruitment trees will be instructed in

how to identify signs of Vaux's swift presence as well as snags and trees with the potential for future use. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to protect and enhance habitat for the Vaux's Swift in the upper Green River watershed.

Rationale and Ecosystem Benefits

The Vaux's swift uses a wide range of managed and unmanaged forest habitats for foraging, but it is very specific in its selection of nest and roost sites; it requires large, hollow ("chimney") snags (Bull 1991) or large decadent trees with pileated woodpecker cavities or natural hollows (Bull and Cooper 1991). Under conventional forest management, these snags and decadent trees are considered hazards to worker safety and forest fire prevention, and so are felled. They are rarely replaced under the short, even-aged rotations typical of the Pacific Northwest, so they can subsequently become limiting factors to the presence of the Vaux's swift. The snag, green recruitment tree, and log retention measure will ensure that large snags and large green recruitment trees are left at the time of harvesting in the Upper HCP Area, and the Vaux's swift nest and roost tree measure will direct the selection of green recruitment trees to with the most potential benefit to the Vaux's swift.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04U

MEASURE: Larch Mountain Salamander Habitat Protection

Tacoma will survey potential Larch Mountain salamander habitat prior to activities that might substantially reduce forest canopy and/or result in substantial disturbance to the substrate. Areas that are surveyed and found to be occupied by Larch Mountain salamanders will be protected as described below. For purposes of this conservation measure, potential habitat is defined as: a) coniferous forest over 100 years of age, or b) any site with greater than 0.25 acre of contiguous substrate of exposed, coarse unconsolidated substrate, regardless of the vegetative cover.

Activities that might substantially reduce forest canopy, remove or disturb coarse woody debris, and/or result in substantial disturbance to the substrate will be preceded by surveys for Larch Mountain salamanders if they are to be conducted in potential habitat. These activities include: a) clearcut harvesting, b) salvage logging, c) commercial thinning, d) new road construction, e) road reconstruction that involves work outside the existing road prism, and f) creation of new rock/gravel extraction sites. The continued use and/or expansion of existing rock/gravel extraction sites will not require surveys.

Potential habitat surveys and habitat protection will occur according to the following steps:

1. **Potential habitat (as defined above) will be surveyed prior to the activities listed above. Surveys will follow 1999 USFS protocol (Crisafulli 1999).**
2. **Potential habitat found to be occupied by Larch Mountain salamanders during surveys will be protected and buffered with 50-foot no-harvest buffers. Except as noted below, none of the activities listed above will occur within the occupied habitat or the buffer.**
3. **The total area protected (including buffer) within any one planned activity area (e.g., harvest unit or planned road segment) will not exceed 10 percent of the total planned activity area. When occupied habitat covers more than 10 percent of the planned activity area, Tacoma and the USFWS will determine which areas will receive protection.**
4. **New roads will be re-routed around occupied Larch Mountain salamander habitat unless alternate road locations would substantially increase the total miles of roads in the affected area, or if alternate locations would have greater impacts to fish, wildlife or water quality.**

Objective

The objective of this measure is to minimize impacts to Larch Mountain salamanders and their habitat in the upper Green River watershed during the course of road construction and other forest management activities.

Rationale

The Larch Mountain salamander is a little-known species that appears to have a strong association with coarse substrates, where it resides in the cool, moist spaces between rocks (Nussbaum et al. 1983; Leonard et al. 1993). Recent evidence also suggests the salamander finds habitat beneath coarse woody debris in mature and late-seral coniferous forest (Crisafulli 1999). Habitats of this type often occur in widely scattered patches across the landscape, and it is not known how quickly disturbed habitats can be re-occupied by salamanders from other patches of potential habitat. It is therefore considered important to protect all significant patches of potential habitat, at least until more is known about the habitat requirements, dispersal abilities and full geographic distribution of the species.

A number of other Habitat Conservation Measures will result in the protection of potential Larch Mountain salamander habitat. HCM 3-01B will protect several thousand acres of habitat in the Natural Zone, including several hundred acres of mature upland coniferous forest in the upper reaches of the watershed. HCM 3-01C

will provide similar protection to coniferous forest stands over 100 years old in the Conservation Zone. HCM 3-01J will protect upland sites with low productivity (several of which are on coarse, rocky soils) as UMAs, and HCM 3-02A will protect several hundred acres of upland forest that may be potential Larch Mountain salamander habitat along streams. The only areas not covered by these other measures are the lands in the Commercial and Conservation zones that will be subject to commercial timber harvesting, road construction and gravel extraction. HCM 3-04U will cover these areas.

All areas of potential habitat (as defined above) will be surveyed for Larch Mountain salamanders, and protected from disturbance if found to be occupied. Certain areas and activities will be explicitly or implicitly excluded from the survey requirement. Forest stands less than 100 years old will not require surveys because they have less residual woody debris, and thus less potential for supporting Larch Mountain salamanders (Crisafulli 1999). Contiguous areas of coarse soil less than 0.25 acre in size will not require surveys because they collectively amount to a small amount of potential habitat, but they could result in a substantial amount of survey effort. Areas subject to salvage harvesting from roads will not require surveys because the potential for ground disturbance will be negligible. Lastly, existing rock and gravel extraction sites are excluded from the survey requirement because they are already being developed as gravel sources (disturbed sites) and these facilities are essential to the proper maintenance of roads in the watershed. There are currently 11 developed rock/gravel extraction sites on the covered lands, for a total of 26 acres. The closing of an existing rock/gravel extraction site would require the opening of another, and likely result in greater overall impact. Conversely, the total amount of potential Larch Mountain salamander habitat represented by these developed sites is small.

~~**HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04U**~~

~~**MEASURE: Larch Mountain Salamander Habitat Protection**~~

~~Tacoma will conduct no timber harvesting, yarding, road construction, or aerial application of pesticides, herbicides, or fertilizers in forested talus fields of 1.0 acre or larger and within 100 feet (average distance) of unforested talus fields of 0.5 acre or larger in size. All existing roads through forested talus fields of 1.0 acre or larger and unforested talus fields of 0.5 acre or larger will be abandoned if alternate roads are available. For purposes of implementing this measure, forested talus fields shall mean areas of unconsolidated rock with forest overstory canopy closure less than or equal to 30 percent, and unforested talus shall mean unconsolidated rock slopes. An unforested talus field shall end at the treeline where there is clearly evidence of a~~

~~forest talus edge. Talus extending into the forested stand beyond this edge shall be considered forested talus, and not subject to the buffering requirement of this measure. When delineating buffers around unforested talus fields, consideration shall be given to topographic features and the aspect that best protects the microclimate in and around the talus field, with preference given for retaining trees on the south and west sides. Tacoma will fund all the costs associated with this measure.~~

~~Objective~~

~~The objective of this measure is to protect Larch Mountain salamander habitat in the upper Green River watershed from human alteration and destruction.~~

~~Rationale and Ecosystem Benefits~~

~~The Larch Mountain salamander is a little-known species that appears to have a strong association with talus substrates (Nussbaum et al. 1983; Leonard et al. 1993) where it resides in the cool, moist spaces between the rocks. Habitats of this type often occur in widely disjunct patches across the landscape, and it is not known how quickly disturbed habitats can be re-occupied by salamanders from other patches of suitable habitat. It is therefore considered important to protect all significant patches of suitable habitat, at least until more is known about the habitat requirements, dispersal abilities and full geographic distribution of the species. HCM 3-04U will provide for the protection of all talus patches that are at least 0.5 acre in size. Protection of smaller patches would be difficult to administer (because of the difficulty finding and delineating them).~~

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04V

MEASURE: Sightings of Covered Species

Tacoma will notify the USFWS in a timely manner of any reported sighting of a spotted owl, marbled murrelet, grizzly bear, gray wolf, Pacific fisher, California wolverine, or Canada lynx in the Upper HCP Area. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to assist the USFWS and other responsible resource agencies in the effective management of federally-listed species in the upper Green River watershed.

Rationale and Ecosystem Benefits

The spotted owl, marbled murrelet, grizzly bear, gray wolf, Pacific fisher, California wolverine, and Canada lynx are all rare in the Washington Cascades. Each confirmed sighting of these species is important to ongoing conservation and recovery efforts. The USFWS, which coordinates recovery efforts for listed species, should be informed as quickly as possible for any occurrences so that appropriate research and management actions can be taken.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04W

MEASURE: Seasonal Protection of Occupied Marbled Murrelet Nesting Habitat

Tacoma will conduct no timber felling, yarding, or road construction within 0.25 mile, no aerial application of pesticides within 0.5 mile, and no blasting within 1.0 mile of habitat where "occupancy" by nesting marbled murrelets has been documented, in habitat where "presence" of marbled murrelets has been reported but occupancy status has not been determined**, and in suitable nesting habitat that has not been surveyed for marbled murrelets**. This avoidance measure will be implemented all times of day from 1 April through 5 August, and from 1 hour before sunrise and 2 hours after sunrise and 1 hour before sunset until 1 hour after sunset from 6 August through 15 September. Tacoma will fund all costs associated with this measure.

Objective

The objective of this measure is to protect nesting marbled murrelets in the upper Green River watershed from human disturbance.

Rational and Ecosystem Benefits

Marbled murrelets recently have been detected in the upper Green River Watershed, and "occupancy" behaviors have been observed on federal lands adjacent to the Covered Lands. "Occupancy" is presented to indicate nesting, according to the Pacific Seabird Group (PSG) survey protocol (Ralph et al. 1994). While the effects of human activity on nesting marbled murrelets are not well understood, it is assumed that disturbance of the type created by logging, road construction, and the use of low-flying aircraft can contribute to nest failure. Tacoma anticipates no harvest of suitable marbled murrelet nesting habitat on the Covered Lands during the term of the ITP, but management activities on the Covered Lands could occur near occupied marbled murrelet nesting habitat on adjacent lands. This mitigation measure will avoid disturbance-related impacts to nesting marbled murrelets on and near the Covered Lands. **All information available to Tacoma, including the results of marbled murrelet surveys conducted by**

neighboring landowners, will be used to determine when and where this measure should be applied.

HABITAT CONSERVATION MEASURE NUMBER: HCM 3-04X

MEASURE: Site-Specific Protection of Northwestern Pond Turtles

Tacoma will develop site-specific protection plans to minimize impacts to Northwestern pond turtles if the turtles are found to occur on or near the Covered Lands and it is determined that one or more of the covered activities has the potential to impact the turtles. Protection plans will be prepared in cooperation with the WDFW, USFWS, and NMFS and will address only the performance of Covered Activities on the Covered Lands.

Objective

The objective of this measure is to protect Northwestern pond turtles and their habitat on the covered lands from human alteration and destruction.

~~*Objective*~~

~~The objective of this measure is to protect denning California wolverines in the upper Green River watershed from human disturbance.~~

Rationale and Ecosystem Benefits

Northwestern pond turtles are not currently believed to occur on or near the Covered Lands, but the potential exists for them to occur in the future. The development of site-specific protection plans in coordination with the appropriate agencies offers the best opportunity for effective mitigation.

Literature Cited

References cited in this chapter are provided in Chapter 10 of the HCP. Chapters 5, 6, and 8 of the HCP contain the primary commitments of Tacoma in support of its application for an ITP. The Underline and Strikeout versions of HCP Chapters 5, 6, and 8 are included in the FEIS to identify changes in the Draft HCP that were made in response to public comments and additional analyses conducted by the Services. A final HCP, including an updated list of references cited in each chapter, will be issued when the Services have reached a decision regarding issuance of an ITP.

FIGURES

TABLES

5. Habitat Conservation Measures to be Implemented Under the HCP

The Green River has been and will continue to be the main source of water for the City of Tacoma. The Green River likewise represents a regionally important ecosystem that supports economically, culturally, and recreationally significant populations of anadromous and resident salmonids (see Chapter 4). This chapter describes specific habitat conservation measures that Tacoma is financially committed (either solely or in combination with others) to implement as part of this Habitat Conservation Plan (HCP).

Although Tacoma is concerned about ensuring certainty in meeting existing and future demands for water, Tacoma has long recognized that potential conflicts exist between meeting such demands and the needs of the ecosystem of the Green River basin. As a result, Tacoma has taken an active part in identifying impacts related to its operations and activities, and developing measures to avoid, minimize, or otherwise mitigate for such impacts. These measures have been developed through many years of active discussions with Tribal, federal, state, county, and private interest group representatives, and meetings and discussions with individuals comprising scientific advisory groups formed to address technical environmental issues. Because Howard Hanson Dam (HHD) is a major influence on the structure and function of the Green River ecosystem, and HHD operations affect Tacoma's water withdrawals, many of the measures were generally developed in close collaboration with the U.S. Army Corps of Engineers (USACE).

An important backdrop to this list of conservation measures is understanding that, since the 1980s, Tacoma has been actively working with the Muckleshoot Indian Tribe (MIT) to remedy past fish and wildlife damages related to the construction and operation of the Tacoma Supply Intake at River Mile (RM) 61.0 (Headworks) diversion. The 1995 Muckleshoot Indian Tribe/Tacoma Public Utility[1] Mitigation Agreement (MIT/TPU Agreement) is a substantial commitment by Tacoma directed toward the implementation of a suite of measures that were considered by both parties to compensate for all impacts to the fishery resources associated with Tacoma's operations in the Green River, including the First Diversion Water Right Claim (FDWRC) and the Second Division Water Right (SDWR). The effects of the joint USACE and Tacoma HHD Additional

[1] Tacoma Public Utility, Water Division is now known as Tacoma Water (Tacoma). Since the agreement is a well-recognized document, it will continue to be referenced as the MIT/TPU Agreement.

Water Storage (AWS) project were not addressed by the MIT/TPU Agreement.

In addition to fish and wildlife habitat enhancement measures, Tacoma has committed to: 1) construct a fish ladder and adult collection and trap-and-haul facility to provide passage to adult fish around the Headworks and HHD; 2) higher minimum flows (greater than Washington State instream flow requirements); and 3) provision for either a fish restoration facility designed to rear salmonids using "naturalized" procedures (see HCM 2-05), or comparable funding of other measures targeted toward fisheries enhancement in the Green/Duwamish river system. These measures directly benefit the species for which Incidental Take Permit (ITP) coverage is being sought. Tacoma has also committed to contribute funds for activities conducted by other parties (e.g., MIT, USACE[2]), for the benefit of fish and wildlife resources in the Green River.

Tacoma's habitat conservation measures and stewardship actions are listed in Table 5-1. Because a number of the measures have been jointly sponsored by Tacoma and other parties, the measures can be divided into three types, depending on their focus and where and how benefits are directed:

1) implementation of measures designed to offset or compensate for impacts resulting from a Tacoma water withdrawal action (e.g., withdrawal of water under SDWR) – designated Type 1 measures;

2) contribution of funds and/or implementation of measures designed to offset or compensate for impacts resulting from a non-Tacoma action (e.g., financial support of gravel nourishment measures to offset effects of HHD flood control) – designated Type 2 measures; and

3) implementation of mitigation/restoration measures in the Green River watershed designed to offset impacts of Tacoma non-water withdrawal activities (e.g., forestry operations in the upper watershed) – designated Type 3 measures.

[2] The cost-share arrangement referenced in this document between Tacoma and the USACE is subject to changes in the Water Resource Development Act or other Congressional funding initiatives that may adjust the cost-share formula between the parties.

Table 5-1. Tacoma Water (Tacoma) habitat conservation measures (HCM) to be implemented under the HCP.

Habitat Conservation Measure	Title	Description	Type of Measure[1]	U.S. Army Corps of Engineers AWS Project Number [2]
HCM 1-01	**FDWRC** ~~Minimum~~ Instream Flow ~~Under FDWRC~~ **Commitment**	**Guaranteed continuous** ~~Minimum~~ flow maintained at Auburn, WA gage (stipulated in the MIT/TPU Agreement)	Type 1	N.A.
HCM 1-02	Seasonal Restrictions on SDWR	Minimum flow **restrictions on SDWR withdrawals** ~~maintained~~ at Auburn and Palmer, WA gages (stipulated in the MIT/TPU Agreement)	Type 1	N.A.
HCM 1-03	Tacoma Headworks Upstream Fish Passage Facility	Construction/operation of upstream fish passage facility at Headworks	Type 1	N.A.
HCM 1-04	Tacoma Headworks Downstream Fish Bypass Facility	Installation of screen and fish bypass facility at Headworks	Type 1	N.A.
HCM 1-05	Tacoma Headworks Large Woody Debris (LWD)/Rootwad Placement	Installation of LWD, rootwads and boulders to enhance rearing capacity in Headworks inundation pool	Type 1	N.A.
HCM 2-01	HHD Downstream Fish Passage Facility	Construction/operation of downstream fish passage facility at HHD	Type 2	Mitigation and Restoration FP-A8
HCM 2-02	HHD Non-Dedicated Storage and Flow Management Strategy	Provide opportunity to manage springtime water storage and release at HHD to minimize impacts to salmonids	Type 2	N.A.
HCM 2-03	Upper Watershed Stream, Wetland, and Reservoir Shoreline Rehabilitation Measures	Rehabilitate fish and wildlife habitat in the reservoir inundation zone, riparian areas upstream and downstream of HHD	Type 2	Mitigation and Restoration MS-02, 04, 08 TR-01, 04, 05, 09 VF-05
HCM 2-04	Standing Timber Retention	Retention of 166 acres of deciduous, 48 acres mixed, and 15 acres of conifer forest in the HHD pool inundation zone	Type 2	N.A.

Table 5-1. Tacoma Water (Tacoma) habitat conservation measures (HCM) to be implemented under the HCP.

Habitat Conservation Measure	Title	Description	Type of Measure[1]	U.S. Army Corps of Engineers AWS Project Number [2]
HCM 2-05	Juvenile Salmonid Transport and Release	Transport and release of juvenile salmonids above HHD if determined to be beneficial	Type 2	N.A.
HCM 2-06	Low Flow Augmentation	Option to provide an additional 5,000 ac-ft of water for low flow augmentation	Type 2	USACE 1135
HCM 2-07	Side Channel Re-connection Signani Slough	Re-connect and rehabilitate 3.4 acres of off-channel habitat in Signani Slough (RM 60)	Type 2	Restoration VF-04
HCM 2-08	Downstream Woody Debris Management Program	Introduce woody debris into Green River downstream of Headworks	Type 2	Restoration MS-09
HCM 2-09	Mainstem Gravel Nourishment	Provide up to 3,900 yd^3 gravel into Green River downstream of Headworks	Type 2	Restoration LMS-01, 02, 03, 04
HCM 2-10	Headwater Stream Rehabilitation	Creation of off-channel habitat, installation of LWD/rootwads in Green River, N F Green River, and eight tributaries	Type 2	Restoration MS-03 TR-06, 07
HCM 2-11	Snowpack and Precipitation Monitoring	Install up to three snow pillows in the upper Green River basin	Type 2	N.A.
HCM 3-01 — UPLAND FOREST MANAGEMENT MEASURES				
HCM 3-01A	Upland Forest Management Measures	Management of Tacoma lands within the HCP according to natural, conservation, or commercial designations	Type 3	N.A.
HCM 3-01B	Natural Zone	No timber harvesting except to modify fish or wildlife habitat or remove danger trees along roads	Type 3	N.A.
HCM 3-01C	Conservation Zone	No even-aged harvesting in conifer-dominated stands and no harvesting (except danger tree removal along roads and fish and wildlife habitat modifications) in conifer-dominated stands older than 100 years	Type 3	N.A.
HCM 3-01D	Commercial Zone	Coniferous forests will be managed on an even-aged rotation of 70 years	Type 3	N.A.

Table 5-1. Tacoma Water (Tacoma) habitat conservation measures (HCM) to be implemented under the HCP.

Habitat Conservation Measure	Title	Description	Type of Measure[1]	U.S. Army Corps of Engineers AWS Project Number [2]
HCM 3-01E	Hardwood Conversion	Stands in the conservation and commercial zones dominated by hardwood on sites capable of producing conifers may be converted to conifers by clearcutting	Type 3	N.A.
HCM 3-01F	Salvage Harvesting	Salvage timber harvesting only in forested areas of the Commercial Zone and stands in the Conservation Zone under 100 years old affected by wind-throw, insect infestation, disease, flood or fire according to set prescriptions	Type 3	N.A.
HCM 3-01G	Snags, Green Recruitment Trees and Logs	Tacoma will retain all safe snags and at least four green recruitment trees and four logs per acre, where available	Type 3	N.A.
HCM 3-01H	Harvest Unit Size	Even-aged harvest units will not exceed 40 acres in size	Type 3	N.A.
HCM 3-01I	Even-aged Harvest Unit Adjacency Rule	Even-aged harvesting will occur when the surrounding forest land is fully stocked with trees a minimum of 5 years old and 5 feet high	Type 3	N.A.
HCM 3-01J	Harvest Restrictions on sites with Low Productivity	Timber harvesting will occur only on lands with a Douglas-fir 50-year site index of greater than 80	Type 3	N.A.
HCM 3-01K	Contractor and Logger Awareness	Contractor, loggers, and forestry workers operating in the Upper HCP Area will be required to comply with relevant HCP measures	Type 3	N.A.
HCM 3-01L	Logging Slash Disposal	Slash disposal will not be burned unless burning is part of habitat modification	Type 3	N.A.
HCM 3-01M	Reforestation	All even-aged stands will be re-planted with 300-400 suitable trees per acre by the first spring following harvest	Type 3	N.A.
HCM 3-01N	Harvest on Unstable Slopes	Tacoma will identify potentially unstable landforms and apply general prescriptions developed by Watershed Analysis or site-specific prescriptions developed by a slope stability specialist	Type 3	N.A.

Table 5-1. Tacoma Water (Tacoma) habitat conservation measures (HCM) to be implemented under the HCP.

Habitat Conservation Measure	Title	Description	Type of Measure[1]	U.S. Army Corps of Engineers AWS Project Number [2]
HCM 3-02 — RIPARIAN MANAGEMENT MEASURES				
HCM 3-02A	No-Harvest Riparian Buffers	Tacoma will retain no-harvest buffers along all streams and wetlands in the Upper HCP Area	Type 3	N.A.
HCM 3-02B	Partial Harvest Riparian Buffers	Tacoma will retain partial-harvest riparian buffers outside no-harvest buffers on Type 3 and Type 5 streams	Type 3	N.A.
HCM 3-03 — ROAD CONSTRUCTION AND MAINTENANCE MEASURES				
HCM 3-03A	Watershed Analysis	Tacoma will participate in all Watershed Analyses performed according to the WFPB within the HCP area	Type 3	N.A.
HCM 3-03B	Road Maintenance	Tacoma participate in the development of a Road Sediment Reduction Plan describing the priorities and schedule for road maintenance, improvement and abandonment activities that will be implemented to reduce road sediment inputs.	Type 3	N.A.
HCM 3-03C	Roads Construction on Unstable Landforms	Tacoma will implement all draft and final mass wasting prescriptions specific to new road construction in WAUs where watershed analyses are approved or pending. In WAUs where assessments have not been completed within 2 years following issuance of the ITP, Tacoma will complete a slope stability analysis and develop site-specific prescription for road construction.	Type 3	N.A.
HCM 3-03D	Roads on Side Slopes Greater Than 60 Percent	Tacoma will use full bench construction with no side casting of excavated materials on side slopes greater than 60 percent	Type 3	N.A.
HCM 3-03E	Erosion Control	Tacoma will place mulch and/or grass seed on all road cuts and fills with slopes over 40 percent or near water crossings as well as in areas of severe erosion/slumping danger or above and below roads	Type 3	N.A.

Table 5-1. Tacoma Water (Tacoma) habitat conservation measures (HCM) to be implemented under the HCP.

Habitat Conservation Measure	Title	Description	Type of Measure[1]	U.S. Army Corps of Engineers AWS Project Number [2]
HCM 3-03F	Stream Crossings	When constructing roads through riparian areas, Tacoma will minimize right-of-way clearing, cross streams at right angles, minimize stream disturbances and side-casting of excavated materials, and provide for upstream and downstream passage in fish-bearing streams	Type 3	N.A.
HCM 3-03G	Road Closures	Tacoma will maintain a locked gate to restrict road use except where the USFS requires roads to be open	Type 3	N.A.
HCM 3-03H	Roadside Vegetation	Tacoma will maintain low-growing vegetation along roads to stabilize soils and minimize erosion	Type 3	N.A.
HCM 3-03I	Road Abandonment	Tacoma will abandon roads in the HCP area that are no longer needed for watershed management, forestry operations, or HCP implementation according to a specified schedule	Type 3	N.A.
HCM 3-03J	Culvert Improvements	Tacoma will inventory all roads in the HCP area and identify all culverts that block fish passage within 1 year of issuance of ITP, plans to eliminate blockages will be made within 2 years, and all blockages will be eliminated within 5 years of issuance of an ITP	Type 3	N.A.
HCM 3-04 — SPECIES SPECIFIC MANAGEMENT MEASURES				
HCM 3-04A	Grizzly Bear Den Site Protection	Tacoma will not fell timber, yard timber, construct roads, or apply aerial pesticides within 1 mile of any known active grizzly bear den from 1 October through 31 May; and will contact the USFWS prior to any similar activities within 3 miles of a known den at other times of the year	Type 3	N.A.
HCM 3-04B	Grizzly Bear Sightings	Tacoma will suspend all management activities under its control in the Upper HCP Area within 1 mile of confirmed grizzly bear sightings for 21 days unless activities are necessary for the operation of the water supply project	Type 3	N.A.

Table 5-1. Tacoma Water (Tacoma) habitat conservation measures (HCM) to be implemented under the HCP.

Habitat Conservation Measure	Title	Description	Type of Measure[1]	U.S. Army Corps of Engineers AWS Project Number [2]
HCM 3-04C	Grizzly Bears and Roads	Tacoma will not construct roads across non-forested blueberry and black huckleberry fields, meadows, avalanche chutes, or wetlands in the Upper HCP Area	Type 3	N.A.
HCM 3-04D	Grizzly Bear Visual Screening	Tacoma will retain visual screens along preferred grizzly bear habitat or along roads within 1 mile of said habitat if a grizzly bear is documented in the Green River watershed	Type 3	N.A.
HCM 3-04E	Grizzly Bears and Trash	Tacoma will take measures to prevent the dumping of trash that may attract grizzly bears in the upper watershed	Type 3	N.A.
HCM 3-04F	Grizzly Bears and Firearms	Tacoma will prohibit firearms within vehicles of contractors working for Tacoma in the Upper HCP Area (except in special cases)	Type 3	N.A.
HCM 3-04G	Gray Wolf Den Site Protection	Tacoma will not fell timber, yard timber, construct roads, blast, or apply aerial pesticides within 1.0 mile of any known active gray wolf den from 15 March through 15 July and within 0.25 mile of any known active gray wolf "first" rendezvous sites from 15 May through 15 July	Type 3	N.A.
HCM 3-04H	Pacific Fisher Den Site Protection	Tacoma will not fell timber, yard timber, construct roads, blast, or apply aerial pesticides within 0.5 mile of any known active Pacific fisher den from 1 February through 31 July	Type 3	N.A.
HCM 3-04I	California Wolverine Den Site Protection	Tacoma will not fell timber, yard timber, construct roads, blast, or apply aerial pesticides within 0.5 mile of any known active wolverine den from 1 October through 31 May	Type 3	N.A.
HCM 3-04J	Canada Lynx Den Site Protection	Tacoma will not fell timber, yard timber, construct roads, blast, or apply aerial pesticides within 0.25 mile of any known active Canada lynx den from 1 May through 31 July	Type 3	N.A.

Table 5-1. Tacoma Water (Tacoma) habitat conservation measures (HCM) to be implemented under the HCP.

Habitat Conservation Measure	Title	Description	Type of Measure[1]	U.S. Army Corps of Engineers AWS Project Number [2]
HCM 3-04K	Seasonal Protection of Peregrine Falcon Nests	Tacoma will not fell timber, yard timber, construct roads or apply aerial pesticides within 0.5 mile, or blast within 1.0 mile of any known active peregrine falcon nest from 1 March through 31 July	Type 3	N.A.
HCM 3-04L	Long-Term Protection of Peregrine Falcon Nest Sites	Tacoma will not fell timber or alter habitat within 100 feet of any known peregrine falcon nest site or potential nest cliff greater than 75 feet in height in the Upper HCP Area; and Tacoma will retain large potential perch trees within 660 feet of known peregrine nests	Type 3	N.A.
HCM 3-04M	Seasonal Protection of Bald Eagle Nests and Communal Winter Night Roosts	Tacoma will not fell timber, yard timber, construct roads, or alter habitat within 0.25 mile or aerial spray within 0.5 mile or blast within 1.0 mile of any known active bald eagle nest from 1 January through 15 August or active communal winter night roost at sensitive times of day from 15 November through 15 March	Type 3	N.A.
HCM 3-04N	Long-Term Protection of Bald Eagle Nests and Communal Winter Night Roosts	Tacoma will not fell timber or otherwise alter habitat within ~~330~~ **400** feet of any known bald eagle nest or communal winter night roost in the Upper HCP Area	Type 3	N.A.
HCM 3-04O	Seasonal Protection of Northern Spotted Owl Nests	Tacoma will not fell timber, construct roads or apply aerial pesticides within 0.25 mile, or blast within 1.0 mile of the activity center of any known northern spotted owl pair from 1 March through 30 June	Type 3	N.A.
HCM 3-04P	Long-Term Protection of Northern Spotted Owl Nests	Tacoma will not fell timber or otherwise alter habitat within 660 feet of the activity center of any known northern spotted owl pair or resident single in the Upper HCP Area	Type 3	N.A.

Table 5-1. Tacoma Water (Tacoma) habitat conservation measures (HCM) to be implemented under the HCP.

Habitat Conservation Measure	Title	Description	Type of Measure[1]	U.S. Army Corps of Engineers AWS Project Number [2]
HCM 3-04Q	Seasonal Protection of Northern Goshawk Nests	Tacoma will not fell timber, yard timber or construct roads within 0.25 mile, apply aerial pesticides within 0.5 mile, or blast within 1.0 mile of any known active northern goshawk nest from 1 March through 31 August	Type 3	N.A.
HCM 3-04R	Long-Term Protection of Northern Goshawk Nests	Tacoma will not fell timber or otherwise alter habitat within 660 feet of any known active northern goshawk nest in the Upper HCP Area	Type 3	N.A.
HCM 3-04S	Pileated Woodpecker Nest, Roost, and Foraging Trees	Tacoma will give preference to leaving green recruitment trees with visible signs of pileated woodpecker nesting, roosting, and/or foraging when selecting snags and trees to meet other HCMs	Type 3	N.A.
HCM 3-04T	Vaux's Swift Nest and Roost Trees	Tacoma will give preference to leaving green recruitment trees with visible signs of current Vaux's swift nesting and/or roosting and those with the potential for future use when selecting snags and trees to meet other HCMs	Type 3	N.A.
HCM 3-04U	Larch Mountain Salamander Habitat Protection	Tacoma will not harvest timber, yard timber, construct roads, or apply aerial pesticides, herbicides, or fertilizers within forested talus fields larger than 1.0 acres, and within 100 feet of unforested talus fields of 0.5 acre or more in size and will abandon all existing roads through unforested talus fields of 0.5 acre or more in size	Type 3	N.A.
HCM 3-04V	Sightings of Covered Species	Tacoma will notify the USFWS in a timely manner of any reported sightings of a spotted owl, marbled murrelet, grizzly bear, gray wolf, Pacific fisher, California wolverine, or Canada lynx in the Upper HCP Area	Type 3	N.A.

Table 5-1. Tacoma Water (Tacoma) habitat conservation measures (HCM) to be implemented under the HCP.

Habitat Conservation Measure	Title	Description	Type of Measure[1]	U.S. Army Corps of Engineers AWS Project Number [2]
HCM 3-04W	Seasonal Protection of Occupied marbled Murrelet Nesting Habitat	Tacoma will not fell timber, yard timber, or construct roads within 0.25 mile, apply aerial pesticides within 0.5 miles, or blast within 1.0 mile of suitable marbled murrelet nesting habitat where "occupancy" has been determined or "presence" has been observed but occupancy is undetermined from 1 April through 15 September.	Type 3	N.A.
HCM 3-04X	Site-Specific Protection for Northwestern Pond Turtles	Tacoma, the WDFW, and the Services will cooperatively develop site-specific protection plans for Northwestern pond turtles if the turtles are found to occur on or near the Covered Lands and it is determined the Covered Activities have the potential to impact the turtles.	Type 3	N.A.

[1] Type 1: Protection measure designed to offset impacts of a Tacoma water withdrawal activity.
Type 2: Protection measure designed to offset impacts of a non-Tacoma activity.
Type 3: Protection measures designed to offset impacts of a Tacoma non-water withdrawal activity.

[2] **Project numbers refer to mitigation and restoration measures identified in the Draft Environmental Impact Statement (DEIS) for the Additional Water Storage Project (USACE 1998). Note that during further development of the measures, site designations may change from those identified in the DEIS.**

AWSP	Howard Hanson Dam – Additional Water Storage Project	MS	Mainstem; refers to AWS projects located in the mainstem Green River
FDWRC	First Diversion Water Right Claim	NA	Not Applicable
FP	Fish Passage; refers to an AWS fish passage project	SDWR	Second Diversion Water Right
		TPU	Tacoma Public Utilities
HCM	Habitat Conservation Measure	TR	Tributary; refers to AWS projects located in Green River tributaries
HCP	Habitat Conservation Plan		
HHD	Howard Hanson Dam	USFS	United States Forest Service
ITP	Incidental Take Permit	USFWS	United States Fish and Wildlife Service
LMS	Lower Mainstem; refers to AWS projects located in the mainstem Green River below HHD	VF	Valley Floor; refers to AWS projects located in the Green River valley floor
		WAU	Watershed Administrative Unit
LWD	Large Woody Debris	WFPB	Washington Forest Practices Board
MIT	Muckleshoot Indian Tribe		

Many of the conservation measures described in this chapter have been developed to protect or enhance aquatic, wetland, or upland habitats or to address ecosystem functions such as sediment transport. These measures often benefit many of the species for which Tacoma is seeking coverage under the ITP. For example, maintenance of minimum flows in the middle and lower Green River, while designed to benefit various salmon species covered by the ITP, would also directly benefit other fish, wildlife, and riparian plant communities. Other conservation measures were developed to address habitat or management issues specific to a species, such as **protecting active dens** ~~preventing contractors in the upper watershed from carrying firearms to avoid the incidental shooting~~ of grizzly bears**, Canada lynx and gray wolf**. Where a species is not addressed by a specific conservation measure, general habitat conservation measures were considered to provide adequate protection.

This chapter describes each of the habitat conservation measures and is presented by the "type" of measure as previously described in this subsection. The order of presentation begins with Type 1 measures and extends through Type 3. The primary description of Tacoma's commitment for each measure is contained within textboxes (text outlined by solid black line) located at the beginning of each subsection. Following the textbox, the objective, rationale for implementation of the measure, and the anticipated ecological benefits are presented for each conservation measure. Costs for implementation of the conservation measures are contained in Chapter 8. Each measure has been given an identification number consisting of the letters HCM (Habitat Conservation Measure) followed by a two-digit number (e.g., HCM – XX)

~~This chapter describes each of the habitat conservation measures with reference to the different "types" noted above, the rationale for implementation of the measure, and the anticipated ecological benefits. Costs for implementation of the conservation measures are contained in Chapter 8. Each measure has been given an identification number consisting of the letters HCM (Habitat Conservation Measure) followed by a two-digit number (e.g., HCM – XX). The order of presentation begins with Type 1 measures and extends through Type 3.~~

5.1 Habitat Conservation Measures – Type 1

Type 1 habitat conservation measures are those designed to offset or compensate for impacts resulting from Tacoma water withdrawal activities. For instance, as part of the MIT/TPU Agreement, Tacoma agreed to design, construct, and operate an upstream fish passage facility at its Headworks, the Green River municipal and industrial water supply intake located at RM 61.0. The upstream fish passage facility was one of several measures that were developed as part of the MIT/TPU Agreement that settles Muckleshoot claims against Tacoma, including the FDWRC and the SDWR, arising out

of Tacoma's municipal water supply operations on the Green River. Selected excerpts of the 1995 MIT/TPU Agreement are provided in Appendix B.

5.1.1 Habitat Conservation Measure: HCM 1-01 ~~Minimum~~ FDWRC Instream Flow Commitment ~~Under FDWRC~~

HABITAT CONSERVATION MEASURE NUMBER: HCM 1-01

MEASURE: ~~Minimum~~ FDWRC Instream Flow Commitment ~~Under FDWRC~~

Tacoma will **constrain water withdrawals under the FDWRC to provide guaranteed minimum continuous instream flows** ~~provide for the following minimum instream continuous flows (minimum flow)~~ **(during the period 15 July to 15 September)** at the Auburn, Washington gage (USGS Gage # 12113000) as defined for different summer weather conditions:

Summer Weather Condition	Auburn Instream Flow
Wet Years	350 cfs
Wet to Average Years	300 cfs
Average to Dry Years	250 cfs
Drought Years	250 to 225 cfs, depending on the severity of the drought

Wet, average, dry, and drought weather conditions will be determined by the use of reference zones within Howard Hanson Reservoir that show available storage by date **within the 24,200 acre-foot block of water stored for flow augmentation purposes** (Figure 5-1). Tacoma will have the option to lower the ~~minimum~~ flow requirement to 225 cfs at the Auburn gage during drought conditions. At that time, Tacoma may rely on the South Tacoma well field or other groundwater sources to meet its water supply need, and reduce water withdrawals under the FDWRC. Tacoma may also utilize the South Tacoma well field or other groundwater sources if the USACE augments releases from HHD to meet a 225 cfs flow at Auburn during the summer months and if fall precipitation does not occur in sufficient quantities to meet minimum flows at Palmer. Tacoma will reduce its withdrawal to help prevent a premature drawdown of the reservoir by the USACE. However, thirty days prior to any reduction, Tacoma will convene a drought coordination meeting with the MIT, local, state and federal resource agencies, and USACE to discuss alternatives and seek to institute "consensus derived" water use restrictions. Before lowering the minimum flow in the Green River, Tacoma will institute water use restrictions consistent with an existing water use curtailment plan. ~~At no time will the minimum flow be allowed to drop below 225 cfs at Auburn. The instream flows specified above are supplemental to the instream flow target of 110 cfs at the Palmer U.S. Geological Survey (USGS) Gage 12-106700, as provided by Tacoma and the USACE.~~

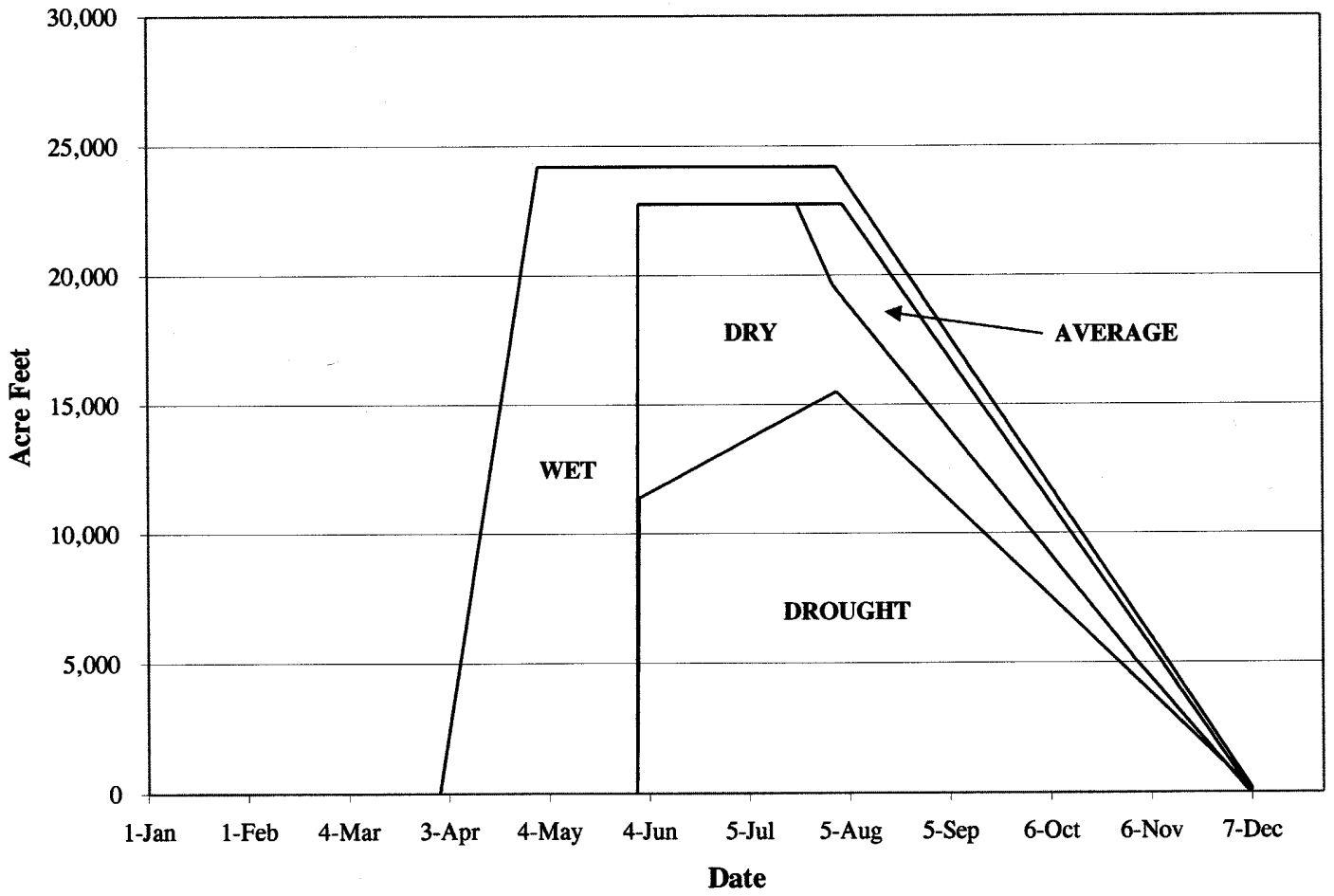

Figure 5-1. Storage reference zones within Howard Hanson Reservoir used to determine minimum flow conditions under yearly wet, average, dry and drought conditions during the period 15 July to 15 September. The storage reference zones pertain to the 24,200 acre-foot block of water stored for flow augmentation purposes.

During the summer period, the instream flow will be maintained above 225 cfs at the Auburn gage even during drought conditions. These commitments by Tacoma are contingent upon

- **continued dedication of 24,200 acre-feet of water stored in Howard Hanson Reservoir for low-flow augmentation to maintain a minimum flow of 110 cfs measured at the USGS Palmer Gage; and**
- **at least 2,500 acre-feet of the 5,000 acre-feet of storage authorized by the Section 1135 project for flow supplementation shall be used to support minimum instream flows during drought conditions.**

Should resource agency decisions on the use of water stored behind Howard Hanson Dam for flow augmentation purposes deviate from these contingencies and thereby limit Tacoma's ability to meet its flow commitment under HCM 1-01, then Tacoma shall be temporarily relieved of its commitment to the extent of the deviation from the contingencies described above.

Tacoma began withdrawing water from the Green River for municipal water supply in 1911 at their Headworks facility at RM 61.0. In 1971, a water right claim of 400 cfs was filed for this diversion (Ecology 1995). Under current conditions, Tacoma withdraws up to 113 cfs under their First Diversion Water Right claim (FDWRC). A water right claim on file with the Washington State of Ecology cannot be validated until an adjudication occurs. As part of HCM 1-01, Tacoma will not pursue adjudication of the full 400 cfs, but will cap their First Diversion Water Right claim at 113 cfs.

Tacoma's FDWRC instream flow commitment is to support flow levels measured at the USGS gage at Auburn. The FDWRC is not constrained by minimum flows prescribed by Ecology for the Green River in the Washington Administrative Code (WAC) 173-509 at either the Palmer or Auburn USGS gages.

North Fork Well Field

In view of potential impacts to instream resources in the North Fork, Tacoma will restrict use of the North Fork well field to periods when the turbidity of Green River surface water supplies approach 5 NTUs, unless emergency conditions require use of the North Fork aquifer in lieu of surface water. This restriction does not apply to occasional pumping of the well field to supply domestic water to Tacoma operations staff living on-site. During the period July 1 through October 31, should turbidity of the mainstem Green River approach 5 NTUs, Tacoma will begin pumping from the North Fork well field at a rate that maintains a maximum pumping-related stage drop of no greater than one inch per hour in the lower North Fork channel at an area of potential salmonid holding refugia to be determined in coordination with the NMFS and USFWS. As the well field is brought on-line, Tacoma will use in-line storage or groundwater supplies in the vicinity of Tacoma (e.g., South Tacoma well field), to meet municipal water demand.

Tacoma will conduct a study to identify the physical effect of the rate of well field pumping on stage changes in the lower North Fork channel in consultation with the NMFS and USFWS within two years following signing of the ITP. The study must be

designed and completed in coordination with the NMFS and USFWS and submitted to the Muckleshoot Indian Tribe and local, state and other federal resource agencies for review and comment. The results of the study will be used to identify a maximum rate of pumping that maintains a pumping-related stage reduction of no greater than one inch per hour in selected adult salmonid refuge area within the lower North Fork channel as determined by the NMFS and USFWS.

Restrictions on the use of the North Fork well field will be subordinate to Tacoma's responsibility to comply with Safe Drinking Water Act Maximum Contaminant Level Limits. In the event that **such emergency** conditions were to occur**,** ~~that are currently unforeseeable,~~ Tacoma agrees to take every effort to avoid actions which would be detrimental to the North Fork Green River's natural resources as the City meets its responsibility to maintain water quality and protect public health. In the event of an ~~unforeseen~~ emergency, Tacoma will consult with the USFWS and NMFS to determine a course of action that will minimize impacts to North Fork fisheries.

Objective

The objective of this measure is to implement guaranteed **continuous** ~~minimum~~ instream flows in the Green River below Tacoma's Headworks to protect important fisheries habitats as specified in an agreement between the Muckleshoot Indian Tribe and Tacoma.

Rationale and Ecosystem Benefits

Instream flows that provide for important fish habitats are fundamental to the long-term protection and propagation of fishery resources in the Green River. Since November 1906, there has been a large decrease in instream flows of the lower Green River. This has resulted from a combination of developments, including but not limited to the diversion (in 1906) of the White River into the Puyallup River (causing a loss of approximately 50 percent of the inflow to the Green/Duwamish estuary), the diversion (in 1912) of the Cedar River into Lake Washington (the Cedar historically flowed into the Black River, which flowed into the Green), and the construction and operation of Tacoma's Headworks diversion (completed in 1913) near Palmer, Washington (see Chapter 4). Overall, 70 percent of the flows of its former watershed have been diverted out of the Green River basin.

From 1911 to 1947, Tacoma diverted up to 85 cubic feet per second (cfs) of water from the Green River at the Headworks under the FDWRC. Since 1948, Tacoma has diverted up to 113 cfs from the Green River under the FDWRC. The combined effects of these actions often resulted in seasonal depletions in instream flows that were detrimental to existing fish populations. The construction and regulation of HHD and reservoir in 1962 afforded some flow protection to downstream fish habitats by providing storage of water

for low flow augmentation to meet a minimum flow target of 110 cfs measured at the USGS gage at Palmer located below Tacoma's Headworks. The instream flow at Palmer may drop below 110 cfs if the inflow to HHD is below 110 cfs and there is insufficient storage to augment flows (e.g., during winter flood control season).

Observation by state and tribal biologists indicated that flows of 110 cfs at Palmer were barely sufficient to provide for passage of adult salmon in the lower river during low flow years and were sometimes insufficient to keep steelhead eggs watered. In 1988, the Washington Department of Ecology (Ecology) completed an instream flow study (using the U.S. Fish and Wildlife Service [USFWS] Physical Habitat Simulation [PHABSIM] methodology [see Chapter 7]) that identified and recommended much higher instream flows (Caldwell and Hirschey 1989).

The guaranteed ~~minimum instream~~ flow~~s~~ **levels** at Auburn specified in this conservation measure were developed as a result of an agreement between MIT and Tacoma~~. and are even higher than those recommended by Ecology.~~ The flows specified in the MIT/TPU Agreement are designed to protect important fishery habitats below Tacoma's Headworks consistent with annual differences in precipitation and flow availability. Because of timing, the ecological benefits of such flows would include improvements in both habitat quantity and quality. With respect to quantity, the flows would provide for a variety of important and seasonally specific life history stage requirements (see Appendix A), including adult salmon holding and spawning habitat, incubation and emergence of steelhead eggs and fry, and upstream passage of adult salmon (see Chapter 7). The flows would also increase the amount of available freshwater habitat in the Green/Duwamish estuary during the summer extreme low flow periods. Benefits related to habitat quality would likely include reductions in water temperatures during the summer months immediately below HHD, increases in or maintenance of dissolved oxygen (DO) levels, and the potential dilution of nutrients and introduced pollutants in the lower Green River. ~~Maintenance of minimum flows will provide a level of resource protection but~~ **Tacoma's commitment to maintain flows during the period 15 July to 15 September will provide a guaranteed level of resource protection. However, this flow commitment** will not provide the full range of flow variability needed to satisfy ecosystem functions. Flow variations, to the extent allowed within the operation**al constraints** of HHD, are provided by other habitat conservation measures.

Tacoma has long encouraged customers to use water efficiently, but increased its focus on conservation during the summer of 1987 when a drought in Puget Sound drastically reduced river flows in the Green River. The late summer drought that year made it difficult for adult chinook salmon to swim upstream to spawn. To facilitate the salmon's

upstream migration, Tacoma reduced the amount of water it withdrew from the river and instituted voluntary and mandated water use restrictions. The less water people use, the more water is available for fish in the Green River. Conservation is especially important in the summer when river flows are at their lowest and water use is at its highest. Tacoma continues to invest considerable resources to educate its customers about the importance of conserving water (see Appendix C, Water Conservation Planning).

North Fork Well Field

Tacoma withdraws water from the North Fork well field to replace or supplement surface water withdrawn from the Green River at the RM 61.5 Headworks. When the turbidity of Green River surface water supplies approach 5 NTUs, the North Fork well field provides a source of clean groundwater that allows Tacoma to provide the public with water that meets rigorous federal and state water quality standards. In general, pumping from the North Fork well field occurs during the late fall, winter and spring when turbidity increases as a result of storm events and resultant periods of high streamflow.

Tacoma's use of the North Fork well field may pose the greatest risk to instream resources during the late summer and early fall. If pumping from the well field was to occur without a storm-related rise in streamflow, adult salmonids holding in the lower North Fork channel could be exposed to channel dewatering. Groundwater outflow below the well field maintains cool water temperatures and provides potentially important adult holding and rearing habitat for salmonids. If pumping from the North Fork well field during the late summer interrupts the outflow of groundwater and reduces flow into the channel; fish holding in the lower North Fork could be trapped in isolated pools or be forced to move downstream to the reservoir.

Restricting withdrawals from the North Fork well field to periods when the turbidity of the mainstem Green River approaches 5 NTUs reduces the risk of impact to instream resources in the lower North Fork to those periods when water withdrawals are needed to avoid violation of Primary Drinking Water Standards. Restricting the pumping of water from the North Fork well field to a rate that maintains a pumping-related stage reduction of no greater than one inch per hour in the lower North Fork channel during the period July 1 though October 31 helps ensure that fish holding in the lower North Fork channel will have the opportunity to move downstream to the reservoir and potentially avoid becoming stranded by pumping-related reductions in stage.

5.1.2 Habitat Conservation Measure: HCM 1-02 Seasonal Restrictions on the Second Diversion Water Right

HABITAT CONSERVATION MEASURE NUMBER: HCM 1-02

MEASURE: Seasonal Restrictions on the Second Diversion Water Right

Before withdrawing water under the SDWR **at an instantaneous rate not to exceed 100 cfs**, Tacoma will **adhere to** ~~meet~~ the following seasonal minimum flows at the Palmer, Washington gage (USGS # 12106700) and Auburn, Washington gage (USGS #12113000):

INSTREAM FLOW BY SEASON REQUIRED FOR SDWR WITHDRAWAL

Season by Dates	Palmer	Auburn
15 July to 15 September	200 cfs	400 cfs
16 September to 31 October	300 cfs	**NA**
~~1 November to 14 July~~	~~300 cfs~~	

NA - Not applicable – The SDWR is not constrained by minimum instream flows in the Green River measured at the USGS gage at Auburn during the period 16 September to 14 July.

These instream flow conditions are in addition to those specified under HCM 1-01 and specify the flow conditions under which **the** SDWR **can be exercised** ~~water can be diverted into P5~~. Both instream flow conditions must be met before SDWR water can be diverted. Thus, if instream flows at Auburn fall below 400 cfs, even if minimum flows for the Palmer gage are achieved, Tacoma may not withdraw water using its SDWR. ~~To the extent that these instream flow requirements are greater than the instream flows prescribed by Ecology (e.g., July through October), these flow requirements will control the diversion action.~~ **Tacoma's exercise of its SDWR will be constrained by the minimum flow requirements identified in this Habitat Conservation Measure or by minimum flows prescribed by Ecology in WAC 173-509, whichever are greater. Tacoma will also work with Ecology to modify minimum flow requirements for the Green River prescribed by Ecology in the WAC to be consistent with the flow commitments identified in this HCP.**

Tacoma's ability to divert its SDWR from the Green River is restricted by the City's 1995 agreement with the Muckleshoot Indian Tribe. That agreement establishes minimum instream flows at both the Palmer and Auburn gauges on the Green River. When flows at either gauge are below the minimum flow levels stated above Tacoma cannot divert water under its SDWR.

Tacoma intends to divert its SDWR to storage behind HHD under the Additional Water Storage Project (AWSP) between February 15 and the point when either 20,000 acre feet have been stored, or when stream flows reach the thresholds specified above. When Green River flows are below the flow thresholds, and Tacoma cannot divert water under its SDWR, the stored water would be used for municipal supply.

Objective

The objective of this measure is to set controls on the withdrawal of Tacoma's SDWR to further ensure protection of fisheries habitat in the Green River.

Rationale and Ecosystem Benefits

This conservation measure is likewise focused on providing instream flows in the lower Green River that promote a healthy instream ecosystem. The measure is complementary to HCM 01 and focuses on seasonal (summer) flow requirements to maintain important fish habitats in the river.

This measure essentially controls when Tacoma will be able to exercise its SDWR. That is, **during the summer period (15 July to 15 September)** both the Palmer and Auburn instream flow requirements noted above must be met before Tacoma can withdraw ~~any~~ water **directly from the Green River under its SDWR.** ~~into P5.~~ **Water stored for municipal supply behind HHD under the AWS project can be used at any time since it represents a prior exercise of the SDWR.** Operationally, as flows in the lower Green River begin to decrease during the late spring and early summer, Tacoma will begin reducing the amount of water it diverts under the SDWR by the amount necessary to meet the specified instream flow requirements. This reduction in diverted flow would continue until the SDWR becomes non-operational (i.e., no water is being diverted), at which time the instream flow conditions specified in HCM 01 would dictate the minimum flows in the lower Green River. **When low instream flows in the Green River prevent Tacoma from exercising its SDWR and withdrawing water directly from the river, Tacoma will use water stored behind HHD for municipal use to meet the demands of its water supply customers.**

The instream flow values specified **in this HCM for the USGS gage at Palmer** ~~for 1 November to 14 July~~ are **equal to or higher than those** ~~the same as those~~ set by Ecology as part of its Instream Resource Protection Program (IRPP) (Chapter 173-509 WAC). ~~During the summer and early fall, the instream flow values under the MIT/TPU Agreement are higher than Ecology's instream flows:~~

Instream Flow Requirements at the USGS gage at Palmer (USGS #12106700) under the **1995** MIT/TPU Agreement and Ecology's Instream Resource Protection Program ~~for a normal water year~~.

Season	MIT/TPU	Ecology **(WAC 173-509**	
		Normal Year	**Critical Year**
15 July to 15 September	200 cfs	150 cfs	**150 cfs**
16 September to 30 September	300 cfs	150 cfs	**150 cfs**
1 October to 15 October	300 cfs	190 cfs	**150 cfs**
16 October to 31 October	300 cfs	240 cfs	**150 cfs**
1 November to 14 July	300 cfs	300 cfs	**150 cfs**
1 November to 15 November	**300 cfs**	**300 cfs**	**190 cfs**
16 November to 30 November	**300 cfs**	**300 cfs**	**240 cfs**
1 December to 14 July	**300 cfs**	**300 cfs**	**300 cfs**

During the period 15 July to 15 September, as a result of the 1995 MIT/TPU Agreement, Tacoma's exercise of its SDWR will also be constrained by minimum flows measured at the USGS gage at Auburn. During the period 15 July to 15 September, Tacoma will not be able to withdraw water directly from the Green River under its SDWR if instream flows drop below 400 cfs measured at the USGS gage at Auburn. This minimum flow is greater than the 300 cfs instream flow requirement identified in the WAC 173-509 for the USGS gage at Auburn during the period 15 July to 15 September. Tacoma's exercise of its SDWR will be constrained by minimum flow requirements identified in HCM 1-02, or by minimum flows prescribed by Ecology in WAC 173-509 for the USGS gage at Palmer, whichever is greater. Except for the commitment in this HCP to constrain its exercise of the SDWR during the period 15 July to 15 September by a minimum flow of 400 cfs measured at the USGS gage at Auburn, Tacoma's SDWR is not constrained by minimum instream flows identified in WAC 173-509 for the Green River at Auburn.

The flows for the period 15 July-15 September approximate those identified as providing peak adult chinook holding, and juvenile chinook, coho, and steelhead rearing habitats in the section of river below the Headworks (Caldwell and Hirschey 1989). The flows specified for Auburn (i.e., 400 cfs) for the same time period (15 July-15 September) likewise protect adult chinook and steelhead holding, and steelhead juvenile habitats. The flows are even greater than those identified as providing peak chinook and coho juvenile habitats (400 cfs vs 220 cfs) (Caldwell and Hirschey 1989). The specified instream flows would protect the habitats in the Green River during the period of time when Tacoma exercises their SDWR. Anticipated benefits include improved, but still only partial protection of steelhead egg incubation and fry emergence, increased juvenile rearing habitats, increased early summer holding habitats for adults and juvenile fish, and increased attraction flows to facilitate adult returns to the river. As in HCM 01, benefits would include those related to water quality improvements, as well as benefits for wildlife and riparian ecosystems.

5.1.3 Habitat Conservation Measure: HCM 1-03
Tacoma Headworks Upstream Fish Passage Facility

HABITAT CONSERVATION MEASURE NUMBER: HCM 1-03

MEASURE: Tacoma Headworks Upstream Fish Passage Facility

Tacoma will modify the existing Headworks facility by increasing the height 6.5 feet and by adding an adult **upstream fish passage facility** ~~fish ladder leading to a trap and holding facility~~. **The proposed facility includes a fish ladder over the Tacoma Headworks combined with a trap-and-haul operation to pass adult fish from the Headworks to above HHD.** In addition, the channel downstream of the diversion dam will be reshaped to provide greater fish attraction to the ladder entrance **(Merry 1995)**. An alternative location for the upstream fish passage facility may also be considered. Any alternative location must satisfy the objective of providing anadromous fish access to the Green River above HHD and must be developed in coordination with the MIT, USACE, WDFW, and the Services. ~~The fish collection facility, consisting of a ladder and holding facilities, will provide for passage of adult steelhead and salmon around HHD (Merry 1995).~~ Adult fish will be transported using a truck specially outfitted to minimize handling and transport stress. Details and final design of this facility will be developed in close coordination and collaboration with MIT, USFWS, USACE, the National Marine Fisheries Service (NMFS), Washington State Department of Fish and Wildlife (WDFW), and other interested parties.

Funding the construction and operation of the upstream fish passage facility is evidence of Tacoma's commitment to long-term measures to help restore anadromous fish production above the USACE's HHD. Once upstream fish passage facilities are completed, the agencies and Tribes with jurisdiction for fisheries management will determine the number and species of fish to be transported into the upper watershed. Determining how many, and which species of fish, should be considered for re-introduction to the upper watershed is a fish management decision that is beyond the responsibility of Tacoma. The MIT and WDFW are co-managers of Green River fish and wildlife resources and together with the NMFS and USFWS will evaluate fisheries aspects of re-introducing anadromous fish into the upper watershed.

Tacoma does not believe re-introduction of anadromous fish to the upper watershed poses a risk to drinking water quality and public health at the numbers, which have been discussed to date. This would include the introduction of up to 6,500 adult coho and 2,300 adult chinook. This level would be reached over a period of years allowing adequate opportunities to assess water quality on an ongoing basis. Tacoma will monitor the effects of fish passage on drinking water quality as part of their surface water treatment operations (see Subsection 6.1.4). If continued monitoring confirms that re-introduction of anadromous fish does not pose a risk to public health, no further action will be taken. If, to adequately protect drinking water quality, it becomes necessary to limit the biomass of adult fish transported into the upper

watershed, Tacoma will coordinate with the NMFS, USFWS, and the fisheries managers before instituting measures to decrease fish passage. As part of the coordination effort, Tacoma will select one or more independent experts to evaluate available options. The independent expert will submit a report to the City, fisheries managers, and public health officials with recommendations as to the level of fish passage that can occur without posing a risk to drinking water quality and public health.

Objective

The objective of this measure is to construct and operate facilities for the upstream movement of adult anadromous fish as part of an overall program to provide anadromous fish access to the Green River above HHD.

Rationale and Ecosystem Benefits

In 1913, construction of Tacoma's Headworks Diversion Dam at RM 61.0 was completed 3.5 miles downstream of the eventual site of HHD. This facility was the first complete barrier to adult salmon and steelhead in the Green River, and eliminated anadromous fish production in the upper watershed. The completion of HHD in 1962 created a further barrier to upstream passage and served to essentially isolate approximately 220 square miles of watershed area (45 percent of the entire Green River basin). Most of the headwater streams in the upper watershed are unconstrained by levees or dikes. Thus, **a portion of the upper watershed** ~~they~~ contains ~~substantial~~ anadromous fish habitat that could be restored to production using an adult passage/trap-and-haul facility at the Headworks. Since 1992, MIT, Tacoma, WDFW, and Trout Unlimited have cooperatively administered a temporary fish ladder and trap-and-haul program. As a pilot program, between 7 and 133 adult steelhead have been captured at the Headworks fish trap and either released above HHD for natural spawning or used as broodstock to produce fry for outplanting in the upper Green River watershed.

Under the proposed measure, adult fish will be collected downstream of the Tacoma Headworks at RM 61.0 and released at the upstream extent of the HHD reservoir in the vicinity of RM 72.0. Upstream migrating adult salmonids could be released into the reach between the Headworks and HHD if deemed beneficial by MIT and WDFW in coordination with the Services. The proposed facility includes a fish ladder over the Tacoma Headworks combined with a trap-and-haul operation from the Headworks to above HHD. The proposed measure was selected in favor of other passage alternatives for several reasons. Although the proposed fish ladder has the physical capability to allow fish to be released immediately above the Headworks, this would only open up 3.5 miles of the mainstem Green River. This area consists of a high-energy confined

channel. Such channels typically route most gravel-size sediment rapidly through the reach, unless there are stable LWD or other obstruction present that form hydraulically protected areas (Paustain et al. 1992). Since the majority of primary spawning and rearing habitats are above HHD, a second upstream fish passage facility consisting of either a very long fish ladder or a trap-and-haul facility would also need to be constructed at HHD to achieve similar benefits to the proposed measure.

Construction of a fish ladder at the Tacoma Headworks combined with a trap-and-haul facility at the HHD would impose higher stress and increased migration delays to upstream migrants than the proposed measure. Adult fish would need to locate and enter a second fishway leading to a trap-and-sorting facility at HHD. Given the configuration of the river and outlet works at HHD, it is likely that a second upstream fish passage facility would need to be located well downstream of HHD; thus further reducing any benefits of allowing salmonids access to the reach between the Headworks and HHD.

There are serious concerns regarding the applicability of conventional fish ladder technology to HHD. The overall height of the Howard Hanson Dam (235-feet) would require a ladder with a length of at least one-mile. Fish attempting to ascend a ladder of this length and height would be exposed to stress and potential water quality deterioration. ~~Tacoma is not aware of any fish ladders constructed to provide adult salmonid fish passage on dams of this height.~~

Another limitation to installing a fish ladder at HHD is the large fluctuation in the reservoir level. Since HHD provides a major flood control function, the water level behind the dam can vary by more than 150 feet during times when adult salmon and steelhead are migrating upstream. During times when the water level is low, the fish that ascended the 235 foot high ladder would then need to be lowered (as much as 150 feet) to the level of the reservoir pool behind the dam. This would require that the adults either be returned in a high velocity slide/chute to the pool level or via some type of mechanical elevator. In either case, the fish would experience additional stress associated with the passage facilities. As an alternative to returning the fish to the lower pool level, the fishway could be extended upstream of the reservoir. However, this would entail extending the fishway approximately 7 miles upstream of the dam, which raises a number of additional concerns about whether effective passage could be achieved (**given concerns about** water temperature and habitat conditions within the fishway). **Tacoma is not aware of any fish ladders constructed to provide adult salmonid passage on dams with the height and range of forebay fluctuation as found at HHD.**

The proposed fish passage facility includes a fish ladder over the Tacoma Headworks combined with a trap-and-haul operation from the Headworks to above HHD. Estimated capital costs for entire facility are $2.53 million. Approximately 63 percent of this $2.53 million is needed for the trap, sorting, and hauling facilities **associated with the transport of adult fish above HHD**. Once constructed, operational costs for the Green River fish ladder would be minimal. In comparison, annual operational costs of transporting adult salmonids via truck are not inconsequential. The proposed measure not only affords passage above the Headworks, but also provides passage around ~~the USACE~~ HHD without imposing additional delays and stress to the fish.

Tacoma supports the full utilization of the upper Green River watershed for anadromous fish production, consistent with the continued use of the Green River as a source of drinking water. At this time, the City does not believe re-introduction of anadromous fish to the upper watershed poses a risk to drinking water quality and public health. Most salmon die after spawning, but the carcasses are quickly consumed (Cederholm et al. 1999). In a study of seven streams in the Olympic Peninsula in Washington State, over 90 percent of coho salmon carcasses were not flushed downstream but remained within several hundred yards of the original placement site (Cederholm et al. 1989).

The City of Seattle conducted a risk assessment of potential negative impacts of salmonid passage on safe drinking water as part of their plan to re-introduce adult anadromous salmonids into the upper Cedar River. The City of Seattle determined that while passage of mass-spawning sockeye over their intake would compromise drinking water quality and public health, passage of much less numerous coho, chinook, and steelhead into the Cedar River above their intake was unlikely to present drinking water problems (Manning et al. 1996). There are numerous similarities and several important differences between the two plans to re-introduce salmonids above the respective intakes.

The Cedar River watershed is adjacent to the Green River watershed and both flow westerly into Puget Sound. Plans to re-introduce salmonids into the upper watersheds of both the Cedar and Green rivers have targeted re-introduction of coho, chinook, and steelhead. An estimated 4,500 coho and 1,000 chinook may return to the Cedar River above Lansburg, while an estimated 6,500 coho and 2,300 chinook may return to spawn in the upper Green River watershed. While the upper Green River watershed may have the potential to support higher numbers of coho and chinook than the upper Cedar River, the upper Green River watershed is 1.7 times larger than the Cedar River watershed above Lansburg. Tacoma presently

has allowed the transport of adult steelhead into the upper Green River watershed since 1992.

Seattle's salmonid re-introduction plan for the Cedar River provides a fish ladder to allow adult fish access to the Cedar River immediately upstream of the Lansburg Diversion (City of Seattle 1998). Due to the presence of the USACE's 235-ft high HHD above Tacoma's Headworks, the Green River salmonid re-introduction plan provides for a trap-and-haul facility to move fish past both Tacoma's Headworks and HHD. The reservoir behind HHD and nearly three miles of river between HHD and Tacoma's water intake will allow the natural uptake of nutrients from spawned salmon prior to withdrawal of water for municipal water supply purposes. The reservoir behind HHD and the stream reach between HHD and Tacoma's water intake will also minimize the occurrence of adult salmon immediately upstream of Tacoma's intake. Tacoma will monitor water quality at their Headworks as part of their surface water treatment program to verify safety of the upper Green River as a source of safe drinking water (see Chapter 6.

Construction and operation of a new fish ladder and trap-and-haul facility at the Headworks is instrumental to the restoration of anadromous fish runs into the upper Green River basin, but would represent only a part of the required actions needed to restore anadromy to the upper watershed.

5.1.4 Habitat Conservation Measure: HCM 1-04 Tacoma Headworks Downstream Fish Bypass Facility

HABITAT CONSERVATION MEASURE NUMBER: HCM 1-04

MEASURE: Tacoma Headworks Downstream Fish Bypass Facility

Tacoma will modify the existing Headworks diversion to eliminate the potential that fish could enter the Headworks intake (to be constructed), and to safely bypass them downstream below the diversion. The new Headworks structure will incorporate a non-revolving wedgewire screen with dimensions of approximately 220 feet long, 40 feet wide, and 24 feet deep (see Chapter 4). The intake screen surface will be approximately 120 feet long and 13 feet high (1,300 square feet) (see Chapter 4) and designed to meet State of Washington and NMFS screening criteria (Merry 1995). In addition to the fish screen, the modified facility will consist of a debris/trash rack, fish bypass system, new trashracks, trash raking equipment, stoplogs, and dual slide gates. The modified intake will be 6.5 feet higher than the old intake to compensate for higher water surface elevations resulting from the increase in the diversion dam crest. The screen and bypass system will be operated and maintained continuously whenever water is being diverted into the Headworks. **Debris that collects on the**

trash racks will be returned to the river channel downstream of the Headworks. Tacoma will coordinate with the Services and other agencies with jurisdiction during the design and construction of the Headworks rebuild. In coordination with the Services, Tacoma will rebuild the Headworks to minimize the risk of injury to salmonids passing downstream over the Headworks spillway. Tacoma will fund all the costs associated with this measure.

Objective

The objective of this measure is to provide downstream fish passage at Tacoma's Headworks Dam as part of an overall program to provide anadromous fish access to the Green River above HHD.

Rationale and Ecosystem Benefits

Two routes are currently available to juvenile fish migrating downstream below Tacoma's existing Headworks. The first and safest is direct passage over the dam spillway, which is currently 17 feet high~~ and has a crest length of 150 feet.~~ Reconstruction of the Headworks will raise the diversion by 6.5 feet~~. The additional height is not expected to present a risk of injury or mortality to downstream migrants.~~ **Although fish passing downstream over Tacoma's Headworks are believed to incur little injury or mortality during their transit over the existing spillway, some potential for injury does exist. In general, mortality of juvenile fish passing over dams is a function of the height of the structure, the maximum velocity of water (which is primarily dependent on dam height) and the configuration of the channel immediately downstream of the dam. For small fish (< 100 mm), mortality is near zero, even for falls of approximately 100 feet, provided they land in water. Larger fish (> 300 mm) begin to experience mortality at falls greater than 50 feet (R2 1998). Fish mortality is also influenced by the maximum velocity of the flow passing over a dam. Where flows passing over a dam empty into a deep pool or stilling basin, mortality is essentially zero at velocities less than 40 feet per second (fps); however, shallow flow or obstructions such as exposed rocks below the spillway appear to increase the rate of mortality and injury (R2 1998).**

Although there are no site-specific data on the hydraulic conditions or injury or mortality of fish at the existing Tacoma Headworks diversion dam, information from studies at other projects suggest that the rate of mortality experienced by juvenile fish passing over a 17-foot spillway is probably low. Fish passing through the radial gates at HHD drop 26 feet onto a concrete slab with little apparent injury (Seiler and Neuhauser 1985). However, because the channel configuration downstream of the Headworks diversion dam currently consists of a shallow

concrete apron, it must be assumed that there could be some injury or mortality of juvenile and adult salmonids passing downstream over the Tacoma Headworks under its current configuration at some flows.

Reconstruction of the Headworks as part of the Second Supply Project will raise the diversion by 6.5 to a total height of 23.5 feet. As part of conservation measures HCM 1-03, Tacoma Headworks Upstream Fish Passage Facility and HCM 1-04, Tacoma Headworks Downstream Fish Bypass facility, Tacoma will rebuild its Headworks facility and reconfigure the channel below the Headworks to minimize potential injury associated with downstream passage of salmonids over the Headworks spillway.

The second **avenue of downstream passage** is via the Headworks intake. This intake is 20 feet wide and is located in the right abutment (looking downstream) immediately upstream of the existing diversion dam. Approximately 10 percent of the flow in the Green River during the juvenile chinook outmigration season currently enters Tacoma's Headworks **intake** (calculated assuming 113 cfs withdrawal at the median daily flow 15 March through 16 June). The existing Headworks intake screens do not meet NMFS screen criteria and juvenile salmonids can potentially be entrained or impinged on the intake and killed. The new fish screen and bypass system would be designed to meet federal and state fish protection criteria. This measure therefore represents an important element in the overall restoration of anadromous fish runs into the upper watershed.

5.1.5 Habitat Conservation Measure: HCM 1-05 Tacoma Headworks Large Woody Debris/Rootwad Placement

HABITAT CONSERVATION MEASURE NUMBER: HCM 1-05

MEASURE: Tacoma Headworks Large Woody Debris/Rootwad Placement

Tacoma will place large woody debris (LWD) and rootwads to **improve** ~~provide~~ rearing habitat (for juvenile salmon and trout) within two sections of the inundation pool immediately upstream of the modified Headworks diversion dam. ~~The LWD will consist of fir, hemlock, cedar, or spruce greater than 20 feet long, with a minimum stem diameter of 12 inches. Rootwads will have at least 3 feet of attached stem that is 18 inches in diameter or greater. No more than 18 and no less than six of the debris pieces will be rootwads. Boulders will be placed at the upstream end of the bar at Site 1 to dissipate the energy of high flows sweeping across the bar. In addition, boulders will be incorporated into LWD clusters to provide stability. Boulders will have a minimum diameter of 4 feet and be composed of hard rock.~~ The first site is located near an access road bridge; the site will be flooded to a depth of one to six feet due to

the increase in pool elevation. At this site, approximately 10 boulders and 43 pieces of LWD will be placed within the active channel. The second site is located along the eastern shore of the Green River, near the upper end of the inundation zone. At this site, five pieces of LWD will be cabled along the bank, with each piece individually anchored to boulders to allow some movement at high flows.

The LWD will consist of fir, hemlock, cedar, or spruce greater than 20 feet long, with a minimum stem diameter of 12 inches. Rootwads will have at least 3 feet of attached stem that is 18 inches in diameter or greater. No more than 18 and no less than six of the debris pieces will be rootwads. Boulders will be placed at the upstream end of the bar at Site 1 to dissipate the energy of high flows sweeping across the bar. In addition, boulders will be incorporated into LWD clusters to provide stability. Boulders will have a minimum diameter of 4 feet and be composed of hard rock.

Structures that are deemed non-functional as a result of high flows will be modified or replaced by Tacoma as needed within the first five years following construction (see Chapter 6). Tacoma will also fund one complete replacement within the term of the HCP should deterioration of the materials or flood damage make such an action necessary.

Alternative measures will be implemented if any of the above measures are determined to be infeasible, or not cost-effective during final design, or if environmentally superior measures can be implemented at comparable cost. Any alternate measures will have habitat benefits greater than or equal to the measure originally proposed, and will be reviewed and approved in advance by the NMFS and USFWS. Permits for these projects have already been approved by the USACE, therefore any changes to the existing project designs that may be requested or approved by the Services will also be subject to approval by the USACE.

Objective

The objective of this measure is to improve rearing habitat for juvenile salmonids in the portion of the Green River immediately upstream of Tacoma's Headworks Dam **by increasing cover within the new inundation zone**.

Rationale and Ecosystem Benefits

The Headworks diversion dam will be raised 6.5 feet to accommodate the diversion of the SDWR. Raising the Headworks will inundate an additional 1,800 feet of channel, or approximately 7 acres (FishPro 1995). Currently, the density of LWD within the area upstream of the Headworks is considered low (0.29 pieces per channel width) compared to free-flowing river systems. This is likely due, in part, to the location of HHD 3.5 miles

upstream (which blocks recruitment of LWD from the upper watershed), as well as past logging practices (CH2M Hill et al. 1996a; Fuerstenberg et al. 1996).

Placement of LWD and large boulders in the inundation pool will increase the density of LWD and create additional in-channel rearing habitats. ~~Large woody debris has been shown to be an important element of healthy anadromous salmonid-bearing streams. Functionally, LWD has been shown to: provide cover for juvenile salmonids, serve as media for invertebrate production and certain riparian plant communities, and create velocity breaks that cause localized deposition of sediments, including spawning gravels. Bisson et al. (1987) noted that along with fish habitat formation, LWD is often associated with the control of sediment and organic matter storage, modification of water quality, and the formation of pools.~~ At some time during their rearing periods, all juvenile salmonids prefer areas in the stream where they can find shelter from velocity and predators while remaining close to a food source (Chapman 1966).

Large rivers such as the mainstem Green River easily transport even the largest pieces of LWD. In these channels, wood is characteristically distributed in infrequent jams composed of numerous pieces of wood (Cederholm et al. 1997; Bisson et al. 1987). Because of the high stream power and confined nature of this reach, LWD would be expected to remain stable only along channel margins, oriented parallel or subparallel to the direction of flow.

Site 1 consists of a low terrace that is approximately 650 feet long and 25 to 100 feet wide. This site will be flooded to a depth of one to six feet as a result of the pool raise. Approximately 10 large boulders (diameter $\geq$ 4 feet) will be placed at the upstream end of the bar to help reduce the erosive energy of high velocity flows sweeping over the bar. Because the channel is wide and has a high transport capacity at Site 1, LWD will be placed in groups to form a series of small, stable jams along the channel margin. Grouping LWD will increase the habitat value and habitat forming function of the relatively small pieces of LWD, in addition to promoting structure stability. Stems will be oriented generally parallel to the flow, with rootwads on the upstream end. Individual pieces of LWD will be cabled to each other and secured to large placed boulders or to stable living conifer trees on the bank. Some movement of the LWD/boulder groups is expected following high flows, as the collections of LWD assume a more natural position. This series of small jams located along the upper channel margin is expected to result in the formation of alcoves and small backwater pools with LWD cover that will provide rearing habitat and refugia for juvenile salmonids at high pool elevations after the diversion dam is raised.

Performance criteria established in the Hydraulic Project Approval (HPA) require that all structures must be able to withstand 100-year peak flows. To this end, Tacoma will also inspect the structures following all flow events with a return interval of 20 years or more as measured at Howard Hanson Dam (see Chapter 6). If the structures fail to meet the stability criteria during the first five years, Tacoma will repair or replace them, modifying the design criteria as necessary in consultation with NMFS and USFWS. After the first five years, Tacoma will provide funding for one additional replacement of the structures, should they decay, or fail following large floods. Should the structures fail more than once during years 6 through 50 of the HCP, habitat benefits of these structures will be reduced.

Site 2 is located at the upper end of the inundation zone. Channel morphology at the site consists of a run/riffle that has formed just downstream of a bar that projects into the flow. The bar creates a relatively protected site where LWD will provide cover and further reduce velocities. Five pieces of LWD will be placed oriented roughly parallel to the flow with rootwads on the upstream end. Each piece of LWD will be loosely cabled to boulder deadmen placed on the bank, allowing the pieces to rise and fall with the flow, and assume a more natural position along the bank. LWD will be placed such that they remain wet during summer low flows. Adding habitat structure at this site is expected to improve rearing habitat at both high and low flows, and to provide a refuge so that fish are not displaced to the inundation pool during high flows.

Tacoma has also pledged to fund two additional habitat rehabilitation projects in the middle Green River; however, these two projects are not included as specific commitments within the HCP. The first of these projects involves providing fish passage to a right-bank off-channel pond (approximately 2 acres in size) at RM 58.5 that is currently disconnected from the mainstem Green River by an inactive beaver dam. The second project involves the rehabilitation of 31 acres of wetland and riparian floodplain at RM 32.9 (Auburn Narrows) consisting of the creation of 5.5 acres of palustrine forest and scrub-shrub wetland, conversion of 1.7 acres of abandoned pasture/emergent wetland habitat to palustrine forested and scrub-shrub wetland habitat, rehabilitation of 2.2 acres of existing wetland habitat, re-establishment of native riparian forest and shrub habitat on 16.4 acres of floodplain, and re-establishment of 5.3 acres of upland forested and shrub plant habitat as riparian buffer. This project may also include development of side channels or beaded ponds that will serve as off-channel habitat suitable for use by rearing salmonids. Tacoma has not included these projects in the HCP because they are located on lands not owned by the City. These projects are part of a cooperative effort with the

USACE and King County, and specific commitments to project objectives and conceptual designs may change prior to implementation. In view of the lack of City control over the land and the uncertainty regarding project objectives, Tacoma has not included them in the HCP. However, Tacoma is still committed to implementing the projects as part of mitigation for the Second Supply Project.

Placement of LWD and boulders in the inundation pool will provide shelter and create important juvenile rearing habitats in that segment of the Green River. Rehabilitation of off-channel habitat elsewhere in the Green River will also increase the amount of juvenile rearing habitat. This habitat conservation measure is expected to benefit downstream migrating juvenile salmonids as well as resident fish. Species benefiting from this measure will include steelhead trout, chinook and coho salmon, cutthroat trout, and resident rainbow trout. These habitat rehabilitation projects have been designed to mitigate for the effects of habitat alteration related to modification of the Headworks.

5.2 Habitat Conservation Measures – Type 2

Type 2 habitat conservation measures are those designed to offset or compensate for impacts resulting from activities carried out by parties other than Tacoma but for which Tacoma is providing a portion of the funding. For instance, construction and operation of HHD for Green River flood control has interrupted the transport of gravel-sized and larger sediments. Construction and operation of HHD is a USACE activity; however, as local sponsor of the AWS project, Tacoma is providing funds to place gravels in the middle Green River channel.

5.2.1 Habitat Conservation Measure: HCM 2-01 Howard Hanson Dam Downstream Fish Passage Facility

HABITAT CONSERVATION MEASURE NUMBER: HCM 2-01

MEASURE: Howard Hanson Dam Downstream Fish Passage Facility

As local sponsor of the AWS project, Tacoma will provide funding support to the USACE to design, construct, and operate a fish passage facility at HHD to increase the survival of salmonids migrating downstream from the upper Green River watershed. Major components of the fish passage facility include a new tower and wet well, a floating fish collector, a fish lock, a discharge conduit, and a fish transport pipeline. The design consists of a combination floating modular incline screen, fish bypass, and single lock facility. The facility will collect fish from 6-20 feet in the water column at all pool elevations (1,070-1,167 feet), and is designed to handle 1,200 cfs

while meeting biological screening criteria. Four new buildings are also proposed as part of the fish collection facility. These are an administration building, a maintenance building, a monitoring building, and a generator building. An access bridge will provide vehicle, utility, and personnel access to the new facility.

Objective

The objective of this measure is to provide downstream fish passage at HHD as part of an overall program to provide anadromous fish access to the Green River above HHD.

Rationale and Ecosystem Benefits

The upstream fish passage facility at the Headworks will provide adult anadromous fish access to the upper watershed. A downstream fish passage facility is also needed to safely pass outmigrating fish through the HHD project. Currently, juvenile salmon and steelhead migrating from the upper Green River to lower river rearing areas or migrating to salt water must pass through one of two HHD outlets (the flood control tunnel or a 48-inch-diameter bypass pipe). The flood control tunnel (1,035 feet) is regulated by two large radial gates. ~~that control the discharge by presenting a barrier to flow.~~ At **release** flows **of** less than 500 cfs, the bypass pipe is used (1,069 feet). Refill of the project typically occurs between early April through June when the pool is filled from low pool (1,070 feet) to the full conservation pool (1,141 feet; plus 3 to 5 feet for debris removal). Spring refill coincides with the main outmigration period of juvenile salmonids. As the pool fills, the outlets are submerged to depths of 35 to 112 feet. As inflow to the reservoir recedes, outflow from the dam is routed to the bypass pipe (flows less than 500 cfs).

Beginning in 1982, juvenile coho and chinook salmon and steelhead trout have been re-introduced into the upper watershed as a means to assess the ability of the existing configuration and operating plan of HHD to pass juvenile fish. Current annual survival of juvenile salmon and steelhead migrating through HHD outlets is estimated between 5 and 25 percent based on a fish passage model and on-site monitoring data (Dilley and Wunderlich 1992, 1993). The low survival rate is primarily a function of two factors: the spring refill of the reservoir submerging the dam outlets and the low survival of juveniles as they pass through the outlets. Juvenile fish require a near surface-outlet ~~(typically 5 to 20 feet deep)~~ with a high discharge capacity outlet (exact volumes depend on site conditions). Therefore, at a time when fish need high flows and a shallow outlet, the project is reducing outflow (refill) and creating a deeper outlet (from 35 to 112 feet deep). During outmigration fish may not find or be willing to use outlets that are deeply submerged. Fish that are delayed or entrapped beyond a certain time may not migrate to

salt water and may not contribute to the returning adult population. Fish that sound (dive) to reach the outlet pipe experience high mortality from impacts at sharp bends or turns within the bypass. Direct mortality in the bypass pipe can range from 1 percent to 100 percent depending on the amount of flow, water temperature, pool elevation, and time of year.

The new downstream fish passage facility is designed to provide much higher success of juvenile outmigration and to accommodate the higher water levels and changes in refill timing under the AWS project Phase I. With the floating fish collector and fish lock compensating for changes in reservoir level, previous problems with early refill of the reservoir on outmigration should be minimized. The fish passage structure (described in Chapter 4.2) has an operating flow range between 400 cfs and 1,200 cfs. The target design flow was approximately 1,200 cfs, which is the 50 percent exceedance flow for April and May during the peak outmigration of salmonid juvenile.

In the majority of years, releases from HHD will improve (decrease) instream temperatures up to 6 miles downstream of the dam. **The intake of the proposed downstream fish passage facility will be capable of operating at a range of depths. This flexibility in depth of submergence will allow for improved temperature control during the summer.** ~~Blending of surface and deeper water would occur sometime in July. After this time, t~~**T**he meeting of temperature requirements could constrain the use of the fish passage facility **in late summer**. To address these constraints, daily monitoring of outflow temperatures and fish passage will be required, as will close coordination with resource agency biologists.

Although the strategy for operating HHD to meet downstream flow needs during the conservation storage period will evolve through adaptive management, an experimental flow management strategy has been developed using blocks of dedicated and non-dedicated storage (see next HCM). As information and understanding of the relationships between the managed flow regime and the biotic resources of the Green River increases, the operation of the HHD can be refined within the range of legal and institutional requirements to balance needs of various fish species, life stages, and water supply.

This habitat conservation measure is intended to offset impacts of the HHD, a USACE activity that has direct benefits to Tacoma. The proposed downstream fish passage facility will address the effects of increased reservoir storage for water supply and storage for low flow augmentation to benefit fisheries resources. Tacoma will also provide funding to support development and implementation of a research program (see Chapter 6).

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FIGURES

TABLES

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6. Monitoring and Research Program

Monitoring and evaluation of the habitat conservation measures identified in Chapter 5 is integral to the success of this HCP. Monitoring is required to ensure measures are implemented according to specified standards. Measures must also be evaluated to ensure the results conform to expectations. In some cases, conservation measures are innovative or experimental in nature and may require testing that potentially leads to adaptive management to achieve desired results. Monitoring and evaluation of the habitat conservation measures provide the Services the certainty that the measures achieve the anticipated level of impact minimization and mitigation required under Section 10 of the Endangered Species Act.

This chapter describes monitoring and research measures that Tacoma has agreed to fund solely or jointly (in conjunction with the U.S. Army Corps of Engineers [1] (USACE) and other federal agencies) as part of this HCP. The measures have been subdivided into three major types: compliance monitoring to ensure conservation measures are implemented according to specified standards; effectiveness monitoring to provide feedback to improve performance and functionality of measures where Tacoma is responsible for ensuring results; and research designed to provide resource agencies and the Muckleshoot Indian Tribe (MIT) information needed to adaptively manage the natural resources of the Green River on a real-time basis (Figure 6-1). Monitoring will continue for the duration of the **Incidental Take Permit** (ITP), or until full compliance with the criteria and commitments identified in the following sections is achieved.

Compliance Monitoring

Compliance monitoring measures are designed to provide documentation to the Services that the conservation measures have been implemented as specified in the HCP. Compliance criteria, developed in cooperation with the Services, ensure that:

- engineered structures, such the fish ladder and fish screens meet design criteria;

[1] The cost-share percentages referenced in this document between Tacoma Water and the USACE are subject to changes in the Water Resource Development Act or other Congressional funding initiatives, which may adjust the cost-share formula between the parties.

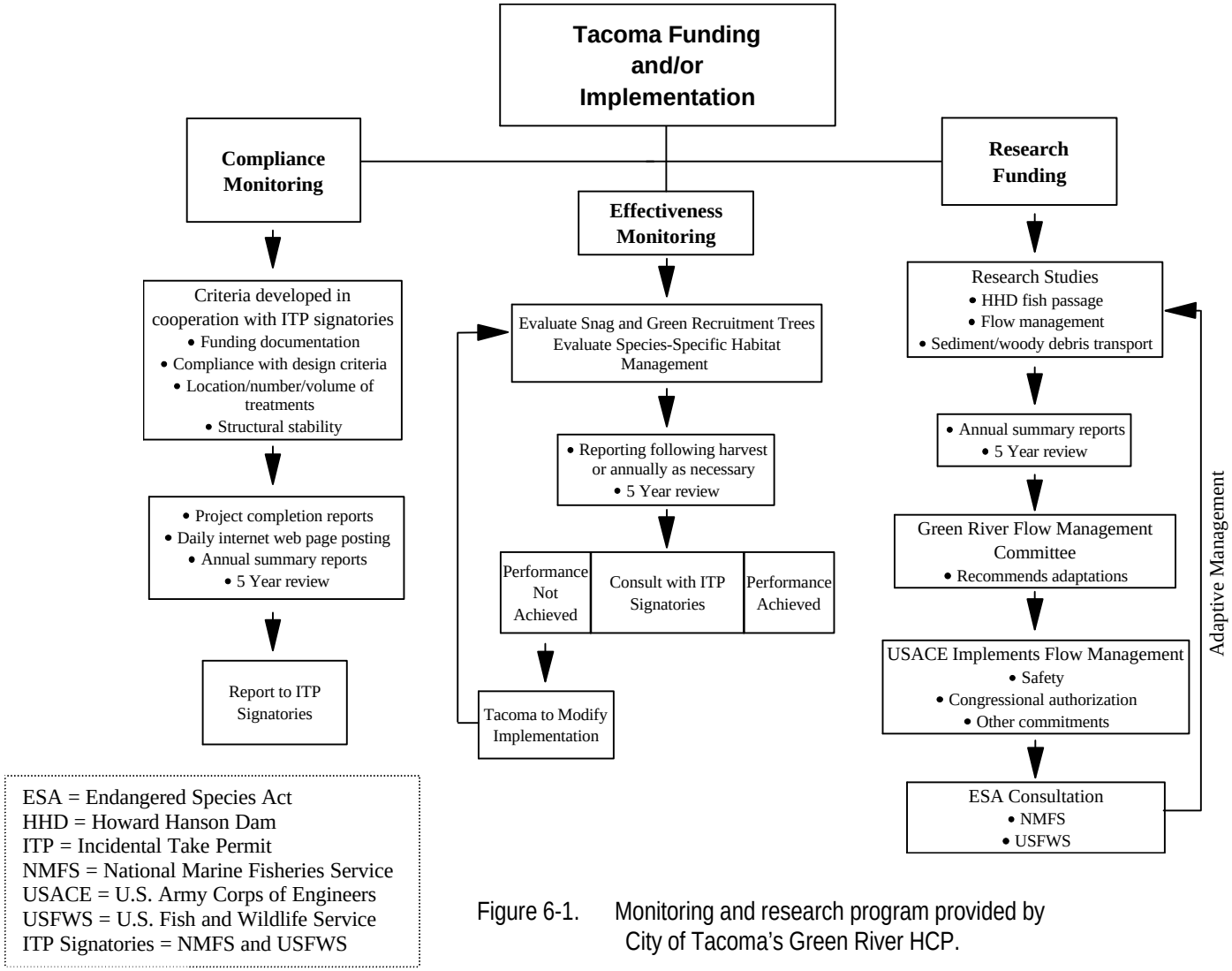

Figure 6-1. Monitoring and research program provided by City of Tacoma's Green River HCP.

- the number, size, location and stability of stream rehabilitation measures such as woody debris, sediment, and vegetation plantings satisfy specified commitments;
- management activities within the HCP area comply with specified constraints or restrictions; and
- resource utilization, such as water withdrawals and timber harvest, are accomplished within established limitations.

Evidence of compliance with the HCP requirements will be documented through a combination of project completion reports, internet web page postings, or annual summaries. Compliance will be evaluated at five-year intervals in cooperation with the Services. Provided that Tacoma has implemented the measures as specified, no further action will be necessary beyond reporting requirements specified in individual measures. Funds required to implement compliance monitoring will be provided by Tacoma solely or in conjunction with other funding agencies. Cost-reductions identified through increased efficiencies, competitive bids, or coordinated efforts with ongoing project operations will accrue to Tacoma or other funding agencies.

Effectiveness Monitoring

Monitoring and adaptive management are a process for combining scientific research with applied management. It is used to address uncertainty about the response of natural ecosystems to management activities while management continues (Halbert 1993). Under an adaptive management process, management actions are treated as a series of experiments, and the results of those "experiments" are scientifically analyzed and used to guide future management.

Effectiveness monitoring measures are used to evaluate whether conservation measures have achieved the specified resource objective. The end result of effectiveness monitoring is to facilitate adaptations if the original measure proves inadequate. Effectiveness monitoring for this HCP includes only those management activities for which uncertainty exists regarding the outcome, and which Tacoma has complete responsibility. Effectiveness monitoring of conservation measures undertaken as part of the AWS project will be addressed by the USACE and the Services during Section 7 consultation. Tacoma's participation as local sponsor and via this HCP is limited to providing partial funding to support necessary monitoring and adaptive management. Adherence to funding commitments will be documented as part of compliance monitoring.

Criteria for effectiveness monitoring measures included as part of this HCP will be developed in coordination with the Services. The results of effectiveness monitoring activities will be reviewed in coordination with the Services at five-year intervals, and if necessary, conservation measures that are judged to be ineffective will be modified. Effectiveness monitoring activities will continue until the Services are satisfied that the measures are achieving the desired resource objective.

Funds required to implement effectiveness monitoring for this HCP will be provided solely by Tacoma. Cost-reductions identified through increased efficiencies, competitive bids, or coordinated efforts with ongoing project operations will accrue to Tacoma.

Research

Conservation measures for which there is currently little biological uncertainty (e.g., screening criteria at Tacoma's Headworks) will be implemented as described in this HCP, with compliance monitoring to ensure implementation of the measure. Where Tacoma is responsible for ensuring effectiveness of a measure (e.g., snag creation), effectiveness monitoring and adaptive management will be implemented. Research is a third category under Tacoma's Green River monitoring and research program and represents the majority of the funding commitment.

Tacoma has committed to several conservation measures associated with facilities operated by other parties (e.g., USACE operation of HHD). Tacoma has also committed to conservation measures where resource agencies and the MIT have been provided the opportunity to identify and recommend adaptive management options with the approval of the NMFS and USFWS (e.g., springtime refill at HHD). For conservation measures where agencies and the MIT are responsible for adaptively managing a resource, Tacoma has committed to funding research to provide them with feedback on the results of their actions.

Tacoma may modify implementation of the HCP, if requested by the NMFS and USFWS, based on the results of the research measures. Tacoma may also modify implementation of the HCP, if requested by the NMFS and USFWS, based on the consensus of the USACE and the Green River Flow Management Committee. However, any modifications to the conservation measures identified in the HCP shall not represent additional commitments of money, water, or other resources without the consent of Tacoma. Recommendations by the USACE and the Green River Flow Management Committee regarding implementation of the HCP or the USACE's operation of HHD cannot preclude or restrict Tacoma's ability to withdraw water to an extent greater than that agreed to as part of HCMs 1-01 and 1-02 in Chapter 5 of the HCP.

Within the financial limitations described in Chapter 8, Tacoma agrees to fund all or part of the various research activities. A research fund will be established by Tacoma as part of this HCP to allow research activities to continue through the 50-year term of the HCP (see Chapter 8). The research fund will allow flexibility in the apportionment of funds between research efforts as new information becomes available and research priorities change. Cost-savings identified through increased efficiencies, competitive bids, or coordinated efforts with other monitoring programs (e.g., King County restoration efforts) will accrue to the research fund. Should funds in excess of the financial commitments identified in Chapter 8 be required to evaluate project impacts or potential restoration measures, the funds must come from sources other than the City of Tacoma.

Annual funding of the research efforts will begin immediately following construction of the HHD Additional Water Storage project (AWS project). During the first ten years of the AWS project, the research fund will be managed by the USACE. During this initial period, the Green River Flow Management Committee will recommend the design and implementation of research activities to the USACE. The USACE will distribute funds or implement the research studies pending approval of the NMFS and the USFWS. During or following this initial ten-year period, the USACE and the City of Tacoma may designate an alternate agency to manage the research fund pending approval of the NMFS and the USFWS. An independent scientific panel could also be formed to guide research activities pending approval of the NMFS and the USFWS.

The intent of the research fund is to allow the NMFS and the USFWS, and with their approval the Green River Flow Management Committee, the opportunity to design and implement an annual Green River research program. In the absence of recommendations of the Green River Flow Management Committee, Tacoma is committed to implementing the monitoring and research program described in this HCP. Details of the research program have been identified in the following section. Additional details will be developed in coordination with the NMFS and USFWS, the USACE, and the Green River Flow Management Committee during the preliminary engineering and design phase of the AWS project. The USACE and Tacoma may modify the research program, in coordination with the Green River Flow Management Committee, provided the NMFS and USFWS concur. Any modification to the research program shall not represent additional commitments of money, water, or other resources without the consent of Tacoma. Tacoma's monetary commitment is identified in Chapter 8 of this HCP.

Based on the results of the research, the Green River Flow Management Committee can recommend adaptations in the USACE's water storage and release schedule for Howard

Hanson Dam. However, responsibility for operation of Howard Hanson Dam, including the reservoir storage and release schedule, lies with the USACE. The USACE, in turn, must comply with project purposes as identified by congressional authorization and must abide by NMFS and USFWS direction through Section 7 consultation under the Endangered Species Act.

Research will address three primary areas of uncertainty:

1) downstream fish passage at HHD (including reservoir and dam passage);
2) flow management in the middle and lower Green River; and
3) sediment and woody debris transport in the mainstem Green River.

Downstream Fish Passage at Howard Hanson Dam

Potential restoration of anadromous fish production above the USACE's Howard Hanson Dam is one of the primary conservation measures of this HCP. While restoration of anadromous fish production to the upper Green River watershed offers great promise, achieving the full benefit of fish passage restoration measures will require close monitoring and evaluation of the downstream passage of salmonids as they enter and pass through the reservoir and dam. Achieving successful downstream passage will require research and evaluation to balance successful passage of outmigrating salmonids through Howard Hanson Dam and reservoir with potentially conflicting requirements to protect downstream fish and wildlife resources.

A variety of measures have been proposed as part of the AWS project to evaluate and monitor outmigrating salmonids. Monitoring measures proposed as part of the AWS project include using nets to sample juvenile salmonids as they enter the reservoir, hydroacoustic surveys to identify fish distribution as they pass through the reservoir and dam, and operation of fish sampling facilities to recapture marked fish to assess passage survival. Tacoma's commitment under this HCP is to provide funding support for downstream fish passage research as local sponsor of the AWS project. Some details of the proposed downstream fish passage-monitoring plan have been identified, but additional details will be developed during the pre-construction engineering and design (PED) phase of the AWS project. The results of research and evaluation measures will be used by the resource agencies and MIT to recommend modifications to the proposed storage and refill rules governing operation of Howard Hanson Dam. Viable contingencies include changes to storage timing, refill rate, duration of refill and route of water released from HHD.

Both the USACE and Tacoma have committed to funding downstream fish passage research measures as part of the AWS project. Tacoma's commitment under this HCP will be to fund a portion of the research effort as the local project sponsor. Through the first ten years following construction of the AWS project, Tacoma will provide funding support for downstream fish passage research measures at the level identified in Chapter 8 of this HCP. Funding support for downstream fish passage research during years 11 through 50 of the AWS project must be provided by other funding entities. Should funds in excess of those identified in Chapter 8 be necessary to fully examine downstream fish passage issues during the first ten years of the AWS project, funds must be acquired from cost-savings or re-apportionment from other monitoring measures or by conducting monitoring on a more infrequent but more intensive schedule.

Flow Management

Tacoma is seeking a federal permit under the Endangered Species Act to cover water withdrawals associated with supplying municipal water to regional customers. One effect of these water withdrawals is to alter streamflow in the mainstem Green River below Tacoma's Headworks. To provide resource agencies and the MIT with information to better manage instream resources, Tacoma has committed to funding a series of flow management research measures. Flow management research measures identified in this HCP include identifying the physical and biological relationships between mainstem, lateral and side-channel habitats in the middle Green River, identifying the timing and location of spawning salmon and steelhead, and sampling outmigrating juvenile salmonids to identify their outmigration timing, distribution, and survival.

Flow management research measures will provide the NMFS and USFWS and other members of the Green River Flow Management Committee with the knowledge and opportunity to better manage flows and fisheries in the Green River. Using the results of the research measures, they can adaptively manage the Green River flow regime and recommend changes in the storage and release of water from HHD to benefit instream resources. Potential flow management opportunities include maintenance of alternate base flows, capture or release of freshets, and flow augmentation to protect steelhead redds or side channel rearing areas. Many details of the proposed flow management research program are described in this HCP. Additional details will be developed in coordination with the USACE, Services, MIT, WDFW, and King County during the preliminary engineering and design phase of the AWS project.

Some of the flow management research measures contained in this HCP represent joint funding efforts by the USACE and Tacoma as part of the AWS project. Other measures represent commitments by Tacoma as part of prior agreements with the MIT. As described in Chapter 8 of this HCP, Tacoma's commitment to flow management research is to fund a portion of the research effort through the first ten years following construction of the AWS project. Within the funding limits identified in Chapter 8, Tacoma will also provide complete funding for flow management research measures during years 11 through 50 of the AWS project. Should funds in excess of those identified in Chapter 8 be necessary to fully examine specific aspects of flow management issues, funds must be acquired from cost-savings or re-apportionment from other research measures, or by conducting research on a less frequent but more intensive schedule.

Flow management research activities identified in this HCP will be complementary to ongoing salmon and steelhead spawning surveys and other monitoring activities conducted by state and tribal fisheries managers. Streamflow, channel configuration, biotic indices, and water quality parameters are also monitored by various federal, state and local jurisdictions responsible for flood control, public health, and the environment. Coordination with other entities will be critical to maximizing the benefits of conservation measures identified in this HCP (see following section on Basin-Wide Coordination).

Sediment and Woody Debris Transport

The original construction and continued operation of the USACE's HHD interrupts the delivery of gravel-sized and larger sediments and woody debris to the middle and lower Green River. Tacoma and the USACE, as part of the AWS project, have committed to placing quantities of gravel-sized sediments and woody debris below Tacoma's Headworks. The intent is to restore a measure of the natural transport function lost by construction and operation of HHD. Tacoma's commitment, as identified in Chapter 5 of this HCP, is limited to transport and placement of specified quantities of material. Tacoma's gravel and woody debris conservation measures do not commit to a specified level of conservation performance. For instance, Tacoma's gravel nourishment conservation measure stipulates that the addition of 3,900 yd^3 of gravel may be insufficient to fully restore sediment transport functions in the Green River. Tacoma's commitment for sediment and woody debris research is also limited to a specified contribution of funds.

Sediment and woody debris research will identify the amount and composition of sediment and woody debris materials stored in the middle Green River downstream of the input sites. Assuming approval of the Services, information gathered through research efforts will be made available to the Green River Flow Management Committee to allow resource managers to evaluate sediment and woody debris transport alternatives. Potential changes to the sediment and woody debris measures include adaptations to the timing, location, and method of placement of sediments and woody materials. Through the first ten years following construction of the AWS project, Tacoma will provide funding support for sediment and debris transport research as identified in Chapter 8 of this HCP. Should additional funds be necessary to examine sediment or woody debris transport on a basin-wide scale, or if additional funds are needed to expand the evaluation of biological effectiveness, funds must be acquired from cost-savings or re-apportionment from other research measures or by conducting research on a more infrequent but more intensive schedule.

Basin-Wide Coordination

Tacoma presently owns lands that make up about ten percent of the upper Green River watershed, or about five percent of the entire Green River basin (Ryan 1996, Wiggins et al. 1995). Plum Creek Timber Company, U.S. Forest Service, Washington State, King County, Weyerhaeuser, Boeing, and the cities of Auburn, Kent, and Tukwila also own or have jurisdiction over large portions of the Green River basin. In response to the listing of Puget Sound chinook under the Endangered Species Act, many of these entities are committing to increased monitoring efforts to evaluate the effect of their activities on listed species. The widespread interest in monitoring Green River natural resources offers the opportunity to optimize efforts through coordination. Coordination also helps avoid duplication of effort and may provide the opportunity to combine funds to address basin-wide issues or to shift monitoring funds to areas of greatest need.

Collaboration and coordination of monitoring efforts is especially important when addressing issues that extend beyond the immediate effects of a single agency or landowner. Rehabilitation of natural stream processes may involve solutions with potentially significant ramifications. For instance, the sediment transport regime in the Green River is affected by almost all landowners in the basin. The original construction and operation of the Howard Hanson Dam was a combined effort of the USACE and King County. Howard Hanson Dam presently blocks the downstream transport of gravel-sized and larger sediments. While Howard Hanson Dam serves to trap sediment, historic forestry practices in the upper watershed have changed the rate of sediment

delivery into the Howard Hanson Reservoir. Efforts to re-initiate gravel transport below HHD must not only consider the historic and future rate of sediment movement from the upper watershed, but must also consider the existing and future rate of sediment contributions from downstream tributaries. Land use practices in sub-basins such as Newaukum, Soos, Springbrook, and Mill Creeks have changed the rate and size distribution of sediments supplied to the mainstem Green River downstream of HHD. While individual landowners and jurisdictional agencies may affect only a small portion of the basin, each contributes to a basin-wide problem.

Increasing the rate of sediment supply to the Green River below HHD may affect the channel capacity in the lower river. Downstream landowners will want assurances that their needs for flood protection are addressed. The effect of placing sediment below HHD may also change depending on the change in sediment contribution from lower basin tributaries. Rehabilitation of the Green River sediment transport regime is but one example of the benefits of basin-wide coordination in developing solutions to natural resource issues.

In addition to enhancing the cost-effectiveness and efficiency of monitoring efforts, coordination among various parties in the Green River basin would help ensure that management actions support complementary restoration goals. Tacoma's conservation measures identified in Chapter 5 provide the opportunity to protect ecosystem functions in the middle and lower watershed, and to restore anadromous fish production to the upper watershed. As described in Chapter 4, flood control, urbanization, timber harvest, hatchery practices, fisheries harvest, and land-use changes will all influence the effectiveness of measures implemented by Tacoma to protect and restore ecosystem functions. The relative success of conservation measures will be determined not only by Tacoma's implementation of those measures, but by water control, land-use, and natural resource management decisions outside the control of the City. Recovery of Green River ecosystem functions to the extent practicable within the present land-uses of the basin will require coordination with tribal, federal, state and local jurisdictions with resource management responsibilities.

While decisions regarding the operation of Howard Hanson Dam are ultimately the responsibility of the USACE and the Services (through Section 7 consultation), Tacoma believes that establishment of a Green River basin coordinating committee would enhance the synergistic benefits of conservation measures identified in Chapter 5. However, the establishment of such a committee is not the responsibility of Tacoma, and is therefore beyond the scope of this HCP. An ad hoc committee of tribal, state, and federal agency representatives presently coordinate fish harvest and hatchery

management decisions. An informal Green River Flow Management Committee also exists to review and coordinate flow management decisions with the USACE. A basin-wide coordinating committee could address the interaction of instream flow, habitat, harvest, and hatchery issues in the Green River, and be instrumental in maximizing the resource benefits of the conservation measures provided in this HCP. Such a committee could be set up as part of the WRIA 9 planning process or similar mechanisms.

One objective of a Green River basin coordinating committee might be to manage basin-wide monitoring and evaluation programs. Tacoma has structured the monitoring and research program to complement a central committee should one be developed at a later date. The research program is expressly designed so that, with the approval of the NMFS and USFWS, a basin-wide committee can direct annual research funds. In the absence of a formal basin-wide coordinating committee, Tacoma will implement the monitoring and research program as specified in the HCP.

The following sections contain descriptions of individual compliance, effectiveness, and research measures. Each measure has been given an identification number consisting of letters designating the type of monitoring (e.g., CMM for Compliance Monitoring Measure) followed by a two-digit number (e.g., CMM-01). In some cases, there are multiple components for a given monitoring measure; these are given a separate letter code and individually described.

Tacoma recognizes that the sampling and collection of any fish species within the Green River watershed is predicated upon having a valid scientific collection permit issued by the Washington Department of Fish and Wildlife (WDFW). Furthermore, the collection of any federally listed fish species will require acquisition of a federal recovery permit as specified under section 10(a)(1)(A) of the ESA. Prior to initiating any of the monitoring measures that involve fish sampling, Tacoma will obtain all necessary collection permits and authorizations from state and federal resource agencies and Tribes, and will report findings of such samplings in accordance with permit requirements.

Reporting

Reports describing the results of all Compliance, Effectiveness, and Research Monitoring efforts will be submitted to the Services. To minimize repetition, the following text identifies only the Services as primary recipients of monitoring data and reports. However, it is expected that Tacoma or the Services will provide copies of specific reports to other federal, state, and local governments and Indian Tribes who will

participate in coordination activities or who could provide meaningful comments and review. Copies of relevant reports will also be submitted to all state or local agencies with regulatory control over actions undertaken as part of monitoring (e.g., WDFW, as the agency in charge of issuing Hydraulic Project Approvals [HPA], will receive copies of all reports describing proposed or completed instream habitat restoration activities).

The reporting format and schedule for each monitoring or research measure are listed in the summary tables for Sections 6.1, 6.2, and 6.3. Unless otherwise indicated, the results of all monitoring will be summarized and presented to the Services during meetings convened at five-year intervals (five-year reviews). Again, to avoid repetition, the text and tables identify only the Services as participants in five-year reviews. However, contingent upon approval by the Services, Tacoma expects to invite participation in the five-year reviews by the USACE, WDFW, WDOE, WDNR, MIT, King County, and the GRFMC (or a comparable group if one is established). It is expected that the Services will provide copies of monitoring reports and materials distributed at the five-year reviews to those organizations and to other interested parties.

6.1 Compliance Monitoring

A brief description of Compliance Monitoring Measures (CMMs), monitoring criteria, measurement frequency, reporting requirements, and contingencies are described in Table 6-1. Tacoma's specific commitments associated with each measure are contained within a series of outlined textboxes that are presented following the table. The supporting rationale for each monitoring measure is also provided following individual textboxes. All monitoring activities will be summarized in writing and presented to the Services during reviews at five-year intervals. Individual monitoring measures may require more frequent reporting. Monitoring data will be maintained by Tacoma, and will be made available to the Services upon request. Provided that Tacoma has implemented the measures as specified, no further action will be necessary beyond reporting requirements specified in individual measures. Funds required to implement compliance monitoring will be provided by Tacoma solely or in conjunction with the USACE. Cost-reductions identified through increased efficiencies, competitive bids, or coordinated efforts with ongoing project operations will accrue to Tacoma or other funding agency.

Table 6-1. Compliance monitoring to be implemented under Tacoma's Green River HCP.

Measure	Description	Criteria	Measurement Frequency	Reporting	Contingency
CMM-01	Minimum Instream Flow Monitoring	• Green River discharge at Palmer and Auburn available	• Daily	• Post on web page or equivalent public access database	
		• Water supply information available (water diversions and well withdrawal)	• Daily	• Post on web page or equivalent public access database	
		• Document that use restrictions have been implemented if minimum flows in the Green River are lowered to 225 cfs during drought conditions	• As needed	• Written notification to the Services	
		• No water withdrawn under SDWR when flows are < 200 cfs at Palmer or < 400 cfs at Auburn between 15 July and 15 September.	• Daily	• Post on web page or equivalent public access database • Summary plots and tables at 5-year reviews	
		• No water withdrawn under SDWR when flows are < 300 cfs at Palmer between 16 September and 14 July	• Daily	• Post on web page or equivalent public access database • Summary plots and tables at 5-year reviews	
		• Pumping rates are less than the rate required to prevent stage declines in an identified adult salmonid holding area in the North Fork Green River of more than 1-inch per hour between 1 July and 31 October	• Hourly when pumping occurs	• Post on web page or equivalent public access database • Summary plots and tables at 5-year reviews	

Table 6-1. Compliance monitoring to be implemented under Tacoma's Green River HCP.

Measure	Description	Criteria	Measurement Frequency	Reporting	Contingency
CMM-01	Minimum Instream Flow Monitoring (cont.)	• Pumping occurs only when turbidity approach or exceed 5 nephelometric turbidity unit's at the Tacoma Headworks	• Daily	• Post on web page or equivalent public access database • Summary plots and tables at 5-year reviews	
CMM-02	HHD Non-Dedicated Water Storage and Flow Management Monitoring	• Data on quantity of water in non-dedicated, dedicated water supply and dedicated flow augmentation available	• Daily	• Post on web page or equivalent public access database • Summary plots and tables provided to GRFMC monthly from 1 February to 1 July • Report to the Services at 5-year reviews	
CMM-03	Tacoma Headworks Rehabilitation Monitoring	**SITE NO. 1** • Number of pieces of LWD placed: 48 (including at least 6 but no more than 18 rootwads) • LWD species: fir, hemlock, cedar, or spruce • LWD length ≥20 ft • LWD diameter (minimum) ≥12 inches • Rootwad: diameter at base of bole ≥18 inches • Rootwad: stem length ≥ 3ft • Boulder size: b-axis ≥ 4 ft	• One-time post-construction	• Project completion report provided to the Services within 6 months of completion	

Table 6-1. Compliance monitoring to be implemented under Tacoma's Green River HCP.

Measure	Description	Criteria	Measurement Frequency	Reporting	Contingency
CMM-03	Tacoma Headworks Rehabilitation Monitoring (cont.)	• Stability Alignment has changed < 20º Location has shifted < 5 meters = 16.4 ft (LWD) or < 2x diameter for boulders Anchor materials intact LWD sound; limited rot or decay Material size similar to installed; no fragmentation	• Inspect in years 1, 3, and 5; thereafter following flows ≥ 20-year flow event as measured at HHD	• Inspection data available on request • Results reported at first 5-year review and 5-year reviews following 20-year flow events	• Repair or replace as needed during first 5 years; funds available for one replacement during years 6-50
		SITE NO. 2			
		• Number of pieces of LWD placed: 5 • LWD species: fir, hemlock, cedar or spruce • LWD length ≥ 20 ft • LWD diameter (minimum) ≥ 12 inches • Rootwad: diameter at base of bole ≥18 inches • Rootwad: stem length ≥ 3 ft • Boulder size: b-axis ≥ 4 ft	• One-time post-construction	• Project completion report provided to the Services within 6 months of completion	
		• Stability Alignment has changed < 20º Location has shifted < 5 meters = 16.4 ft (LWD) or < 2x diameter for boulders Anchor materials intact LWD sound; limited rot or decay Material size similar to installed; no fragmentation	• Inspect in years 1, 3, and 5; thereafter following flows ≥20-year flow event as measured at HHD	• Inspection data available on request • Results reported at first 5-year review and 5-year reviews following 20-year flow events	• Repair or replace as needed during first 5 years; funds available for one replacement during years 6-50

Table 6-1. Compliance monitoring to be implemented under Tacoma's Green River HCP.

Measure	Description	Criteria	Measurement Frequency	Reporting	Contingency
CMM-04	Tacoma Headworks Upstream Fish Passage Facility Monitoring	• Meets facility design criteria developed in cooperation with NMFS, USFWS,WDFW, and MIT prior to construction	• One-time post-construction	• Project completion report provided to the Services	
		• Documentation of daily number and species transported, release locations, and mortality	• Annual	• Results reported at 5-year reviews	• Modify hauling operations or timing in the event of mortality
		• Confirm adults find and enter ladder by identifying presence/absence of adult anadromous salmonids below the Headworks during trap and transport operations	• Years 1 and 2, survey every 7 days during mid-September to mid-November, and April-May	• Results reviewed annually for ladder entrance modifications; reported at 5-year review	• Modify ladder entrance
		• **Confirm that re-introduction of anadromous fish does not pose a risk to public health through degradation of drinking water quality**	• **Daily at the Headworks and weekly at select locations in the upper watershed**	• **Results reviewed annually; increased frequency if public health issues are identified**	• **Contract with independent expert to coordinate with the Services to evaluate options before reducing upstream passage of adult fish**
CMM-05	Tacoma Headworks Downstream Fish Bypass Facility Monitoring	• Meets facility design criteria developed in cooperation with NMFS, USFWS,WDFW, and MIT prior to construction	• One-time post-construction	• Project completion report provided to the Services	• Install baffles or otherwise modify facility to meet design criteria

Table 6-1. Compliance monitoring to be implemented under Tacoma's Green River HCP.

Measure	Description	Criteria	Measurement Frequency	Reporting	Contingency
CMM-06	Monitor the Distribution of Juvenile Fish Released Upstream of HHD	• **Confirm that debris that collects on trash rack and fish screen are passed downstream**	• **Volume of debris manually removed from the trash racks and screens will be recorded as part of maintenance operations as site conditions require**	• **Results will be reported to the Services annually and summarized at the first two 5-year reviews**	
		• **Confirm that modified Headworks spillway is configured to minimize risk of injury to downstream migrants**	• **Spillway passage tests will be conducted within two years of completion of Headworks modifications**	• **Results will be reported to the Services within 6 months of completed tests**	• **Modify Headworks spillway and/or plunge pool conditions**
		• Documentation of funding or implementation of transport and release (if measure is implemented) Map of release sites Record of number, species, and size of fish released per site	• Record of release process provided to MIT within one week of fish transport	• Financial records available to the Services on request • Results will be reported to the Services annually and summarized at 5-year reviews	

Table 6-1. Compliance monitoring to be implemented under Tacoma's Green River HCP.

Measure	Description	Criteria	Measurement Frequency	Reporting	Contingency
CMM-07	Side Channel Restoration Signani Slough Monitoring	• Meets facility design criteria developed in cooperation with NMFS, USFWS,USACE, WDFW, and MIT prior to construction	• One-time post-construction	• Project completion report provided to the Services within 6 months of completion	
		• Stability for anchored pieces Alignment has changed < 20° Location has shifted < 5 meters is 16.4 ft (LWD) or < 2x diameter for boulders Anchor material, if used, intact LWD sound; limited rot or decay Material size similar to installed Inlet capacity reduced < 20%	• Inspect in years 1, 3, and 5; thereafter following flows ≥ 20-year flow event as measured at HHD	• Inspection data available on request • Results reported at first 5-year review and 5-year reviews following 20-year flow events	• Repair or replace as needed during first 5 years; funds available for one replacement years 6-50
CMM-08	Mainstem Woody Debris Management Monitoring	**LWD ACCOUNTING** • Maintain record of: No. of pieces removed from reservoir No. of pieces for downstream passage No. of pieces for other HCP restoration No. of pieces available for other projects • Copy of LWD availability notification (if applicable)	• Annual update	• Data available to the Services on request; summarize at 5-year reviews	

Table 6-1. Compliance monitoring to be implemented under Tacoma's Green River HCP.

Measure	Description	Criteria	Measurement Frequency	Reporting	Contingency
CMM-08	Mainstem Woody Debris Management Monitoring (cont.)	**UNANCHORED LWD PLACEMENT** • Annual downstream LWD allocation: At least 5 pieces (if available) or 50% of total collected, whichever is greater • Location of wood placement sites • Number of truckloads of small woody debris (up to 5) • Number of pieces of LWD placed • Diameter of LWD: ≥ 1 ft • Length of LWD: ≥ 12 ft	• Annual inspection until all LWD is transported	• Placement data available to the Services on request • Results reported at 5-year review	
		ANCHORED LWD PLACEMENT (if applicable) • Location of wood placement sites • Individual piece or collective volume > 11 yd^3 • Stability Alignment has changed < 20° Location has shifted < 16 ft Anchor material intact LWD sound; limited rot or decay • Material size similar to installed	• One-time post-construction • Inspect in years 1, 3, and 5; thereafter following flows ≥ 20-year flow event as measured at HHD	• Project completion report provided to the Services • Inspection data available on request • Results reported at first 5-year review and 5-year reviews following 20-year flow events	
CMM-09	Mainstem Gravel Nourishment Monitoring	• Location of gravel placement • Volume of gravel placed: ≤ 3,900 yd^3	• Annual inspection of placement sites following high flows	• Purchase records and placement data available to the Services on request • Results reported at 5-year review	

Table 6-1. Compliance monitoring to be implemented under Tacoma's Green River HCP.

Measure	Description	Criteria	Measurement Frequency	Reporting	Contingency
CMM-10	Upper Watershed Stream, Wetland, and Reservoir Shoreline Rehabilitation Monitoring	**HABITAT REHABILITATION (various locations)**			
		• LWD species: fir, hemlock, cedar • LWD (side channels and tribs): Length ≥ 20 ft Diameter ≥ 12 in. Diameter of rootball ≥ 3 ft Frequency (site average) ≥ 2 pieces/channel width • LWD large channels (> 65 ft wide) Volume of piece or group ≥11 yd^3 • Meets design criteria developed in cooperation with NMFS, USFWS, USACE, WDFW, and MIT prior to construction	• One-time post-construction	• Project completion report provided to the Services within 6 months of completion	
		• Stability (all locations) Alignment of LWD structures changed < 20° Location has shifted < 16 ft (LWD) or < 2x diameter for boulders Anchor material intact LWD sound; limited rot or decay Material size similar to installed; no fragmentation	• Inspect in years 1, 3, and 5; thereafter following flows ≥ 20-year flow event as measured at HHD	• Inspection data available on request • Results reported at first 5-year review and 5-year reviews following 20-year flow events	• Repair or replace as needed during first 5 years; funds available for one replacement during years 6-50
		VEGETATION IN INUNDATION POOL • Year 1: ≤ 10% mortality of all plantings • Year 5: ≤ 20% mortality of all plantings • Year 10: ≤ 50% mortality of all plantings • No increase in the percent cover of invasive non-native species in any year	• Single inspection in years 1, 3, 5, 7, 10	• Inspection data available on request; • Results summarized for 5-year reviews in years 5 and 10	• Replant as needed • Implement weed control treatment

Table 6-1. Compliance monitoring to be implemented under Tacoma's Green River HCP.

Measure	Description	Criteria	Measurement Frequency	Reporting	Contingency
CMM-10	Upper Watershed Stream, Wetland, and Reservoir Shoreline Rehabilitation Monitoring (cont.)	**FISH PASSAGE BARRIERS**			
		• Location of barrier culverts	• Year 1	• Map provided to the Services within 6 months following completion of inventory	
		• Treatment prioritization	• Year 2	• List provided to the Services by end of year 2	
		• Culvert design criteria from WDFW (1999)	• As needed	• Records of design calculations, culvert specifications, and post-construction inspection will be maintained and provided to the Services on request	• Repair or replace as needed
				• Culvert replacement activities will be reported 5-year review	

Table 6-1. Compliance monitoring to be implemented under Tacoma's Green River HCP.

Measure	Description	Criteria	Measurement Frequency	Reporting	Contingency
CMM-11	Snowpack and Precipitation Monitoring	• Data on Green River snowpack and precipitation available on public access database	• Daily November through June	• Post on web page on equivalent public access database • Summary plots provided at GRFMC meetings • Report to the Services at 5-year reviews	• Adopt improved measurement technology if it becomes available at a comparable cost
CMM-12	Upland Forest Management Monitoring	**ALL HARVEST UNITS**			
		• Current copy of standard written notification provided to contractors and loggers	• Update as needed	• Presented at first 5-year review and subsequent reviews if modified	
		• Douglas-fir 50-year site index > 80	• Annual summary	• Documentation to the Services on request	
		• At least four green recruitment trees retained per acre (including at least 2 conifer if present) including: 1 ≥ 20" dbh (if present) 1 ≥ 16" dbh (if present) 2 ≥ 12" dbh (if present)	• Inspect and map one year after harvest	• Results summarized at 5-year reviews	
		• At least 6 snags per acre are retained	• Inspect and map following harvest and at 10-year intervals	• Documentation provided to the Services annually on request • Results summarized at 5-year reviews	• Adjust rate of snag recruitment in coordination with the Services

Table 6-1. Compliance monitoring to be implemented under Tacoma's Green River HCP.

Measure	Description	Criteria	Measurement Frequency	Reporting	Contingency
CMM-12	Upland Forest Management Monitoring (cont.)	**UNEVEN-AGE HARVESTING**			
		• No harvest of conifer stands > 100 years old in Conservation Zone	• Annual summary	• Documentation provided to the Services annually on request • Results summarized at 5-year reviews	
		• Unit size ≤ 120 acres	• Annual summary • Calculated at end of each 5-year reporting period		
		• On average, area harvested annually accounts for < 1% of total area in conifer dominated stands in Conservation Zone/year			
		• Planted with 50 to 100 shade tolerant conifers per acre	• Single inspection one year after harvest		• Replant

Table 6-1. Compliance monitoring to be implemented under Tacoma's Green River HCP.

Measure	Description	Criteria	Measurement Frequency	Reporting	Contingency
CMM-12	Upland Forest Management Monitoring (cont.)	**EVEN-AGE HARVESTING** • Units located only in Commercial Zone • On average, accounts for ≤ 1.5% of the conifer dominated stands in Commercial Zone/Year	• Annual summary • Calculated at end of each 5-year reporting period	• Documentation provided to the Services annually on request	
		• Minimum age of conifer dominated stand at harvest = 70 years	• Annual summary • Annual summary	• Results summarized at 5-year reviews • Documentation provided to the Services annually on request	
		• Unit size ≤ 40 acres	• Single inspection one year after harvest	• Documentation provided to the Services annually on request	• Replant
		• Planted with 300 to 400 Douglas-fir, western hemlock, western redcedar, or true fir seedlings per acre		• Documentation provided to the Services annually on request • Results summarized at 5-year reviews	

Table 6-1. Compliance monitoring to be implemented under Tacoma's Green River HCP.

Measure	Description	Criteria	Measurement Frequency	Reporting	Contingency
		SALVAGE HARVEST • Unit size ≤ 120 acres	• Annual summary	• Documentation provided to the Services annually on request	
CMM-12	Upland Forest Management Monitoring (cont.)	**HARDWOOD CONVERSION** • Conducted only in Commercial or Conservation zone	• Annual summary	• Documentation provided to the Services annually on request	
		• Planted with 300 to 400 Douglas-fir, western hemlock, western redcedar, or true fir seedlings per acre	• Single inspection one year after harvest	• Results summarized at 5-year reviews	• Replant
CMM-13	Riparian Buffer Monitoring	• Average no-harvest buffer width (based on at least 10 measurements at intervals ≤100 ft) Type 1 and 2 waters = 200 ft Type 3 waters = 150 ft Type 4 waters = 50 ft **up to 100 ft** Type 5 waters = 25 ft	• Single inspection within one year of harvest	• Raw data provided to the Services annually on request • Results reported at 5-year reviews	
		• Average partial-harvest buffer width (based on at least 10 measurements at intervals ≤100 ft; start at outer edge of no-harvest zone) Type 3 waters = 50 ft Type 5 waters = 25 ft	• Single inspection within one year of harvest	• Raw data provided to the Services annually on request • Results reported at 5-year reviews	

Table 6-1. Compliance monitoring to be implemented under Tacoma's Green River HCP.

Measure	Description	Criteria	Measurement Frequency	Reporting	Contingency
CMM-14	Road Construction and Maintenance Monitoring	• No net increase in permanent road miles **in the Natural Zone** over term of HCP **OR** if increase has occurred over reporting period, TPU will identify roads to be abandoned in the future to ensure compliance	• Calculated at end of each 5-year reporting period	• Results reported at 5-year reviews	
		• Location and configuration of new roads as specified by Watershed Analysis prescriptions	• Single inspection at time of construction	• Documentation provided to the Services annually on request	
CMM-15	Species-Specific Habitat Management Monitoring	• No new roads in berry fields, meadows, avalanche chutes and wetlands	• Annual	• Maps available on request; results reported at 5-year reviews	
		• No harvest within 100 ft of talus fields	• Annual	• Maps available on request; results reported at 5-year reviews	
		• Record of grizzly bear sitings, gray wolf dens, Pacific fisher, California wolverine, Canada lynx provided by watershed inspectors	• Record sightings as they occur; immediate notification of the Services	• Sightings data sheets available on request	• Implement Species-Specific HCMs
		• Annual check with USFWS area biologist and WDFW Priority Habitats database	• Annual	• Results reported at 5-year reviews	• Implement Species-Specific HCMs

6.1.1 Compliance Monitoring Measure CMM-01 Minimum Instream Flow Monitoring

COMPLIANCE MONITORING MEASURE NUMBER: CMM-01

MEASURE: Minimum Instream Flow Monitoring

CMM-01A - Mainstem Green River

Before water can be withdrawn or stored under the Second Diversion Water Right (SDWR), Tacoma shall ensure that the Muckleshoot Indian Tribe (MIT) and federal and state resource agencies have access to the U.S. Geological Survey (USGS) streamflow database, or equivalent source, for the purpose of monitoring streamflow conditions at the Palmer, Washington, (USGS # 12106700) and Auburn, Washington (USGS # 12113000), gage stations (Tacoma 1995). Tacoma shall ensure instream flow levels are measured on a daily basis, as noted under the conditions specified in the Muckleshoot Indian Tribe/Tacoma Public Utilities Agreement (MIT/TPU Agreement), and at both the Palmer and Auburn, Washington gages. The results of such monitoring shall document that Tacoma has taken all steps necessary to comply with seasonal restrictions on the SDWR and the instream flow requirements stipulated in the MIT/TPU agreement. Should Tacoma exercise the option to lower minimum flows to 225 cfs at the Auburn gage during drought conditions, written documentation that water use restrictions have been implemented will be provided to the Services.

Tacoma will make the results of the above monitoring available to the MIT and interested federal and state resource agencies. Furthermore, Tacoma shall also update its system of flow monitoring, as mutually agreed upon by the MIT and federal and state resource agencies, consistent with advances in data transfer technology. As part of this monitoring, Tacoma shall also provide system water supply information (e.g., well and municipal reservoir levels), as requested by MIT and federal and state resource agencies (Tacoma 1995). It is anticipated that access to these data will be provided through an Internet home page with daily updates on reservoir and river conditions.

CMM-01B – North Fork Well Field

Tacoma shall maintain records of withdrawals from the North Fork well field, including the rate of withdrawal on an hourly basis. In addition, daily turbidity values measured at the RM 61.5 Headworks will be maintained. Records of well withdrawals and turbidity readings will be made available to the Services upon request to document compliance.

The results of a study to identify the physical effect of the rate of well field pumping on stage changes in the lower North Fork channel will be provided to the NMFS and USFWS within two years following signing of the ITP. The study must be designed and completed in cooperation with the NMFS and USFWS and submitted to the MIT and local, state, and other federal resource agencies for review and comment. The results of the study will be used to assess the maximum rate of pumping that maintains a pumping-related stage reduction of no greater than one inch per hour in an area of

potential adult salmonid holding refugia the lower North Fork channel. Following completion of the study, documentation of compliance with the 1 July through 31 October ramp rate restrictions will be provided through maintenance of hourly pumping records.

Surveys of adult salmonids holding in the North Fork Green River downstream of the North Fork well field will be conducted during the late summer and fall to quantify the resource potentially at risk. The presence of adult fish in the North Fork Green River downstream of the North Fork well field will be evaluated by pedestrian surveys conducted every 10 days between 1 September and 31 October. Surveys will be conducted for the first five years following completion of the Tacoma Headworks upstream passage facility. The results of these surveys will be reported at the first five-year review, and will be made available to the Services on request.

Objective

Document compliance with minimum flows, water withdrawal restrictions, and pumping rates by making streamflow data and system water supply information available on an Internet home page or other public access database.

Rationale

Mainstem Green River. Tacoma has diverted water from the Green River since 1913, under the First Diversion Water Right claim (FDWRC). Tacoma's FDWRC is not subject to the state of Washington's 1980 minimum instream flow (Caldwell and Hirschey 1989). In 1986, Tacoma was granted an additional water right, the Second Diversion Water Right (SDWR) from the Washington Department of Ecology (Ecology) for up to 100 cfs. In 1995, Tacoma entered into an instream flow agreement with the MIT that conditioned the use of its water rights on minimum flows set forth in the MIT/TPU Agreement (Tacoma 1995). In order to meet this agreement, Tacoma must provide access to USGS streamflow data in the Green River on a daily basis during periods of water withdrawal.

This CMM will be implemented to document that Tacoma is taking all necessary steps to ensure the flow requirements of the MIT/TPU Agreement as described in Table 6-1 and Chapter 5 are met. Information will be available on demand from an Internet web-site or other public access database that is updated daily. Summary plots and tables describing water withdrawals and instream flows will be presented at five-year reviews.

North Fork Well Field. In general, pumping from the North Fork well field occurs during the late fall, winter and spring when streamflow and turbidity are highest. However, periods when well withdrawals would be required to meet drinking water standards have

been documented to occur during September (Noble 1969), at a time when well withdrawals have the potential to impact cool water refugia in the lower North Fork Green River. As part of CMM-01, records of well field use and turbidity readings from the mainstem Green River will ensure that the well field is only used when needed to maintain water quality and protect public health. Documentation of stage changes in response to pumping and information on use of the affected reach by adult salmonids will be used to quantify the resource at risk and assess the magnitude of that potential risk.

6.1.2 Compliance Monitoring Measure CMM-02 Howard Hanson Dam Non-Dedicated Water Storage and Flow Management Monitoring

COMPLIANCE MONITORING MEASURE NUMBER: CMM-02

MEASURE: Howard Hanson Dam Non-Dedicated Water Storage and Flow Management Monitoring

Tacoma has agreed to provide funding support to distribute data for development of an enhanced springtime operating strategy for HHD. Tacoma will post data on the amount of water available for non-dedicated storage, water dedicated to municipal supply, and water dedicated to flow augmentation for instream resources on the web page. A summary of this data will be provided to the Green River Flow Management Committee (GRFMC) on a monthly basis from 1 February through 1 July, and will be presented to the Services during regularly scheduled five-year reviews.

Objective

Provide data on the amount of water available in the dedicated and non-dedicated blocks of water stored in Howard Hanson Reservoir storage to facilitate flow management by the Green River Flow Management Committee (GRFMC).

Rationale

Tacoma is the local sponsor of the Howard Hanson Dam-Additional Water Storage project, and will support the USACE and GRFMC in developing an enhanced springtime operating strategy for HHD. The springtime storage and release strategy will involve management of dedicated and non-dedicated blocks of water that will be used to benefit fisheries resources, as described in HCM 2-02 (Section 5.2.2). To that end, Tacoma has committed to ensuring that data on the quantity of water in non-dedicated, dedicated water supply and dedicated flow augmentation blocks is available to the GRFMC. Providing data on the amount of water in the various storage allocations will assist the GRFMC evaluate management decisions and recommend in-season adjustments.

6.1.3 Compliance Monitoring Measure CMM-03 Tacoma Headworks Rehabilitation Monitoring

COMPLIANCE MONITORING MEASURE NUMBER: CMM-03

MEASURE: Tacoma Headworks Rehabilitation Monitoring

A number of rehabilitation structures (consisting primarily of large woody debris [LWD] and rootwads) will be placed in the Headworks inundation pool to **improve habitat conditions in the reach inundated by** ~~offset environmental impacts associated with~~ the raise in the pool inundation zone. These structures will be monitored to determine their longevity and ability to withstand high flows. The stability of the structures will be assessed using criteria based on the alignment, location, extent of fragmentation or decay, and condition of anchoring materials. Structures that are deemed non-functional as a result of high flows will be modified or replaced by Tacoma as needed within the first five years following construction. Tacoma will also fund one complete replacement within the term of the HCP should deterioration of the materials or flood damage make such an action necessary. The physical stability of the structures will be evaluated in years one, three and five following construction, and after all flows that have a return interval of ≥20 years as measured at HHD.

Objective

Evaluate the physical condition and stability of rehabilitation structures installed in the Headworks inundation pool to confirm that they meet design criteria, and remain stable.

Rationale

The benefits of using LWD to rehabilitate salmonid habitat are well documented (House and Boehne 1986; House et al. 1991; Murphy 1995). For this reason, HCMs that involve placement of LWD are assumed to be effective provided they remain stable and function as intended. Therefore, monitoring for this HCP will be limited to documentation that the structures comply with design and performance criteria.

Design criteria for the Tacoma Headworks Rehabilitation Measure are described in detail in the Final Second Supply Project Comprehensive On-Site and Off-Site Fish Mitigation report (CH2M Hill 1996). LWD specifications call for a total of 48 pieces of LWD to be placed at two sites within the Headworks reach. The number of pieces required is based on achieving a desired frequency of two pieces per channel width within the Headworks Reach. Large woody debris must be fir, hemlock, cedar or spruce. Logs will have a minimum diameter of 12 inches and be at least 20 feet long. Rootwads will have a

diameter of at least 18 inches at the base of the bole, and a stem that is at least 3 feet long. These pieces are less than the minimum size or volume that qualifies as a "key" piece in the mainstem Green River channel, which is greater than 100 feet wide in the Headworks Reach. However to enhance stability, the LWD will be placed in groups of three to five logs, and attached to each other and to a placed boulder that has a minimum diameter of four feet. At Site 1, which consists of a large point bar, approximately 10 boulders (minimum diameter 4 ft) will be placed at the upstream end to dissipate the energy of high flows sweeping across the bar. At Site 2, five single logs will be placed at the outside of a meander bend, and attached to each other and to boulders that have been placed on the bank.

Compliance with the design criteria will be documented by a one-time inspection of each rehabilitation site immediately following construction. The condition and stability of each structure will be assessed using general criteria developed by Gaboury and Feduk (1996). Structures will be judged stable if they remain within 16.4 feet (5 meters) of their original location, their alignment has changed less than 20 degrees, anchor materials and connections are intact, and the LWD is sound with little rot, decay, or fragmentation. The stability of each rehabilitation structure will be evaluated through field inspections conducted one, three, and five years after construction. Performance criteria established in the HPA require that all structures must be able to withstand 100-year peak flows. To this end, Tacoma will also inspect the structures following all flow events with a return interval of 20 years or more as measured at HHD. If the structures fail to meet the stability criteria during the first five years, Tacoma will repair or replace them, modifying the design criteria as necessary in cooperation with NMFS and USFWS. After the first five years, Tacoma will provide funding for one additional replacement of the structures, should they decay, or fail following large floods.

A post-project completion report, describing any deviations from the original design, will be presented to the Services within six months after the project has been completed. The results of the initial stability inspections will be summarized in a report presented at the first five-year review. Additional inspection reports will be submitted at review periods during which a 20-year flow event has occurred.

6.1.4 Compliance Monitoring Measure CMM-04
Tacoma Headworks Upstream Fish Passage Facility Monitoring

COMPLIANCE MONITORING MEASURE NUMBER: CMM-04

MEASURE: Tacoma Headworks Upstream Fish Passage Facility Monitoring

Following construction of the new fish ladder and trap and haul facility at the Headworks, the structure will be evaluated to ensure that project design criteria are met. Specific facility design criteria, performance standards, and a detailed evaluation approach will be developed in cooperation with the Services, WDFW, and the MIT during engineering and design of the Headworks modifications associated with the SSP.

Observations of fish behavior at the entrance to the fishway will be used to ensure the passage facility complies with the requirement to facilitate safe upstream passage of adult fish. The presence of adult fish in the vicinity of the Headworks will be evaluated by snorkel surveys conducted every seven days from mid-September to mid-November, and in April and May for the first two years of the project, or until satisfactory results are observed, whichever is longer. Successful capture of adult fish in the trap when adults are holding in the immediate vicinity of the Headworks will indicate that the facility is accessible. Congregations of adult anadromous salmonids below the Headworks, in combination with a low capture rate will indicate that design modifications are required. The results of these surveys will be reported to the Services on an annual basis.

Release records, visual observation of fish condition, and a low rate of mortality will be considered evidence that fish are being successfully transported upstream. These data will be summarized annually and reported to the Services at regularly scheduled five-year reviews.

Tacoma will monitor the effects of fish passage on drinking water quality as part of their surface water treatment operations. If continued monitoring confirms that re-introduction of anadromous fish does not pose a risk to public health, no further action will be taken. If, to adequately protect drinking water quality, it becomes necessary to limit the biomass of adult fish transported into the upper watershed, Tacoma will coordinate with the NMFS, USFWS, and the fisheries managers before instituting measures to decrease fish passage.

Objective

Evaluate the upstream Headworks facility following construction to confirm that it meets project design criteria **and that passage of adult fish does not pose a risk to public health**.

Rationale

Construction of a new fish ladder and trap-and-haul facility at the Headworks is instrumental to the successful restoration of anadromous fish runs into the upper Green River. Evaluation of hydraulic conditions over the expected range of flows following construction is required to demonstrate that the facility complies with design criteria. A post project completion report, describing any deviations from the original design and the results of the hydraulic evaluation, will be presented to the Services within one year after the project has been completed. Adjustments of the fishway may be required if fish do not enter the ladder or fail to ascend into the trap. Monitoring the number, behavior, and physical condition of adult salmonids below the Headworks and in the trap will provide evidence that the project design is appropriate and verify the adequacy of the facility.

Tacoma does not believe re-introduction of anadromous fish to the upper watershed poses a risk to drinking water quality and public health at the numbers, which have been described in the DEIS for the AWS project. This would include the introduction of up to 6,500 adult coho and 2,300 adult chinook. This level would be reached over a period of years allowing adequate opportunities to assess water quality on an ongoing basis. Tacoma will monitor the effects of fish passage on drinking water quality as part of their surface water treatment operations. Measurements will be taken daily at the Headworks and weekly at select locations within the upper watershed. If continued monitoring confirms that re-introduction of anadromous fish does not pose a risk to public health, no further action will be taken. If, to adequately protect drinking water quality, it becomes necessary to limit the biomass of adult fish transported into the upper watershed, Tacoma will coordinate with the NMFS, USFWS, and the fisheries managers before instituting measures to decrease fish passage. As part of the coordination effort, Tacoma will select one or more independent experts to evaluate available options. The independent expert will submit a report to the City, fisheries managers, and public health officials with recommendations as to the level of fish passage that can occur without posing a risk to drinking water quality and public health.

6.1.5 Compliance Monitoring Measure CMM-05
Tacoma Headworks Downstream Fish Bypass Facility Monitoring

COMPLIANCE MONITORING MEASURE NUMBER: CMM-05

MEASURE: Tacoma Headworks Downstream Fish Bypass Facility Monitoring

The fish screen and bypass facility will be designed based on specifications for fish protection associated with downstream passage facilities developed by the National Marine Fisheries Service (NMFS) and WDFW, and will meet the maximum design

approach velocity requirement of 0.4 feet per second (fps). The configuration and hydraulic performance of the facility under the normal range of flows expected during the period when juvenile salmonids are migrating downstream will be evaluated following construction to confirm that the facility meets design criteria. Specific design criteria, performance standards, and a detailed evaluation approach will be developed during engineering and design of the Headworks modifications associated with the SSP. A post project completion report describing the results of the performance evaluation will be submitted to the Services within one year of project completion.

Wood debris and drift that collects on the trash racks and fish screens must be periodically removed to maintain satisfactory screen operations. Debris that collects on the fish screens will be removed through mechanical or manual maintenance operations and passed downstream. If wood debris or drift are removed or dislodged via manual methods, the volume will be recorded. The number and approximate size of wood pieces dislodged will be totaled on a monthly basis and reported to the Services as part of an annual review. The volume of wood debris and drift manually removed or dislodged will be summarized and reported to the Services during the first two five years reviews. This monitoring measure will continue through the first ten years following completion of the Headworks SSP modifications.

As part of the SSP Headworks modifications, Tacoma will rebuild its Headworks facility and reconfigure the Green River channel below the Headworks. Headworks modifications will be designed to minimize potential injury to salmonids associated with downstream passage over the Headworks spillway. Within two years following completion of the Headworks modifications, Tacoma will conduct a biological test of the modified spillway to demonstrate that the risk of injury to salmonids passing downstream over the spillway has been minimized.

Objective

Evaluate the screen and bypass facility following construction to confirm that it meets design specifications.

Rationale

Screen bypass facilities like the one that will be constructed at the Headworks are a standard design that has been developed and approved by the NMFS and WDFW. Design specifications for the Headworks bypass facility will be developed based on the NMFS criteria. An evaluation of the hydraulic conditions at the completed project will be made over the range of flows expected during downstream migration following construction. A post project completion report, describing the results of the performance evaluation and any deviations from the original design, will be presented to the Services

within one year after the project has been completed. If the completed facility meets the design specifications, no additional monitoring will be conducted.

Woody debris and organic drift materials are an important link between the aquatic and terrestrial environment (see Subsection 5.2.8). Water withdrawn at Tacoma's Headworks is intentionally screened to prevent the intake of adult and juvenile salmonids and wood debris and organic drift. Past maintenance practices at similar water withdrawal facilities have included the collection and disposal of water-borne debris that collect on trash racks and screens. Disposal of these debris interrupts natural stream processes and presents maintenance cost. Tacoma will ensure that wood debris and drift that collect on trash racks and screens at the Headworks will be passed downstream to continue to be transported to downstream habitats.

Although fish passing downstream over Tacoma's Headworks are believed to incur little injury or mortality during their transit over the existing spillway, some potential for injury does exist. The existing concrete gravity diversion dam is 17 feet high. Reconstruction of the Headworks as part of the SSP will raise the diversion by 6.5 to a total height of 23.5 feet. Although there are no site-specific data on the hydraulic conditions or injury or mortality of fish as the existing Tacoma Headworks diversion dam, information from studies at other projects suggest that the rate of mortality experienced by juvenile fish passing over a 23.5-foot spillway is probably low. Tacoma will rebuild its Headworks facility and reconfigure the channel below the Headworks. Design modifications will consider alternative strategies to minimize potential injury associated with downstream passage of salmonids over the Headworks spillway. Within two years following completion of the Headworks modifications, Tacoma will conduct a biological test of the modified spillway to demonstrate that the risk of injury to juvenile salmonids passing downstream over the spillway has been minimized. Before implementing the study, Tacoma will develop a study design in coordination with the Services. The results of the study will be provided to the Services within six months of completing the field portion of the test.

6.1.6 Compliance Monitoring Measure CMM-06
Monitor the Transport of Juvenile Fish to be Released Upstream of HHD

COMPLIANCE MONITORING MEASURE NUMBER: CMM-06

MEASURE: Monitor the Transport of Juvenile Fish to be Released Upstream of HHD

If the Services and the MIT determine that supplementation of juvenile salmonids upstream of HHD is beneficial, Tacoma will provide funds to record the number, size, and the release site of juvenile fish transported by Tacoma and released above HHD.

Objective

Confirm that juvenile salmonids are successfully released upstream of HHD.

Rationale

A map of the release sites, record of the number and species of fish released at each site, and copies of the completed follow-up survey forms will be provided to the Services annually, and the results of the surveys will be summarized and presented for each five-year review following a period when fish are released.

6.1.7 Compliance Monitoring Measure CMM-07
Side Channel Restoration Signani Slough Monitoring

COMPLIANCE MONITORING MEASURE NUMBER: CMM-07

MEASURE: Side Channel Restoration Signani Slough Monitoring

Tacoma will contribute funds to monitor the reconnection of Signani Slough in the middle Green River. The restored channel will be evaluated immediately following construction to document that the site meets the design criteria developed in cooperation with the Services, USACE, WDFW, and MIT. The stability of the structures will be assessed on the basis of: 1) the inlet capacity; 2) alignment, location, extent of fragmentation, or decay of LWD structures; and 3) the condition of anchoring materials. Structures that are deemed non-functional will be modified or replaced by Tacoma as needed within the first five years following construction. Tacoma will also fund one additional complete replacement within the term of the HCP should deterioration of the materials or flood damage make such an action necessary. The physical stability of the structures will be evaluated in years one, three, and five following construction; and after all flows that have a return interval of $\geq$20 years as measured at HHD.

Objective

Assess the physical condition and stability of rehabilitation structures to confirm that they meet design criteria, remain in place, and produce the desired hydraulic conditions.

Rationale

Levees, channel degradation, and controlled flows from HHD have all combined to reduce the Green River's interaction with its former side channel habitats. In 1854, fish could access approximately 1,900 linear miles of stream in the Green River; however, by 1985, only 125 linear miles were still accessible (Fuerstenberg et al. 1996). Off-channel habitat is one obvious source of lost habitat since the turn of the century, and is the focus of the Signani Slough HCM.

The biological benefits of off-channel habitats are well documented (Brown and Hartman 1988; Peterson 1982; Cederholm and Scarlett 1982). For this reason, HCMs that involve reconnection of off-channel habitat and placement of LWD are assumed to be effective provided they remain stable and function as intended. Monitoring for the purposes of this HCP will document that the structures comply with design and performance criteria. However, monitoring of fish use and population surveys may be conducted by Tacoma or other entities as part of the research efforts described in Chapter 6.3. Conceptually, restoration will require breaching the Headworks road in two places and installing two 24- to 48-inch inlet culverts; diverting up to 35 cfs from the mainstem through the side channel; replacing the existing outlet culvert; adding gravels and vegetation; and adding LWD at a frequency of approximately 2 pieces per channel width. Large woody debris placed within Signani Slough will be at least 12 inches in diameter and 20 feet long. Final project design criteria will be developed in cooperation with the Services, USACE, MIT, and state and local agencies prior to construction.

The condition and stability of each structure will be assessed using general criteria developed by Gaboury and Feduk (1996). Large woody debris placed within the side channel will be judged stable if it remains within 16.4 feet (5 meters) of the original location, the alignment has changed less than 20 degrees, anchor cables and connections are intact, and the LWD is sound with little rot, decay or fragmentation. The stability of each enhancement structure will be evaluated through field inspections conducted one, three and five years after construction.

Performance criteria established in the HPA are expected to require that all rehabilitation structures must be able to withstand 100-year peak flows. To this end, Tacoma will also inspect the structures following all flow events with a return interval of 20 years or more

as measured at HHD. If the structures fail to meet the performance and stability criteria during the first five years, Tacoma will repair or replace them, modifying the design criteria as necessary. After the first five years, Tacoma will provide funding for one additional replacement of the structures, should they decay or fail following large floods.

6.1.8 Compliance Monitoring Measure CMM-08 Mainstem Woody Debris Management Monitoring

COMPLIANCE MONITORING MEASURE NUMBER: CMM-08

MEASURE: Mainstem Woody Debris Management Monitoring

The amount of LWD collected from the HHD reservoir each year will be recorded, and a LWD accounting spreadsheet will be developed to track the distribution of LWD. The number of pieces of LWD obtained from the reservoir and allocated to 1) the mainstem Green River woody debris management program, 2) other HCP related conservation measures, 3) non-HCP related habitat restoration projects or MIT cultural use within the Green River basin, 4) ecosystem restoration projects outside of the Green River basin, or 5) disposal will be recorded annually. This spreadsheet and documentation of annual communications with other basin stakeholders regarding the availability of LWD for non-HCP related projects will be provided to the Services on request.

Woody debris allocated to unanchored downstream transport will be placed adjacent to the stream within the active channel and allowed to naturally distribute downstream during high flows in the fall. Tacoma will record the initial placement locations, total volume of small woody debris, and the number and size of pieces of LWD placed at each input site. Each input site will be re-visited the following spring to document the number of unanchored pieces of LWD remaining following high flows. ~~A decrease in the number of pieces of LWD at the input sites will be considered evidence that wood has been recruited to downstream reaches.~~

In addition to or instead of unanchored wood placement, LWD may be anchored at specific locations. If LWD is anchored in the river rather than allowing flows to distribute the pieces naturally, the locations and design criteria applied to each placement site will be recorded.

The location and amounts of small woody debris and unanchored LWD placed and successfully recruited each year will be summarized at each five-year review. If anchored placement is implemented, a post-project completion report describing the location and design of LWD anchoring projects will be presented to the Services within six months after each project has been completed, and the results of stability evaluations will be summarized at five-year reviews.

Objective

Document the annual allocation of LWD collected from the reservoir. Confirm that unanchored LWD placement is transported downstream by high flow events by documenting the volume remaining at placement site location(s) the following spring. Confirm that anchored LWD meets design criteria and remains stable at each anchored placement site.

Rational

The goal of the mainstem woody debris management program is to pass at least 50 percent of the wood collected from behind HHD to downstream reaches. The LWD accounting spreadsheet and communications records will confirm that Tacoma is distributing LWD collected from behind HHD to the mainstem LWD management program or other approved uses in compliance with the ITP. Annual site visits will verify whether unanchored LWD is successfully recruited to the river.

If LWD anchoring is determined to be a preferable means of re-introducing LWD to the middle Green River, post-project completion reports will document that anchored LWD placement projects have complied with design criteria developed in cooperation with the Services, USACE, MIT, and state and local agencies. Compliance with the design criteria will be documented by a one-time inspection of each placement site immediately following construction. The condition and stability of each structure will be assessed using general criteria developed by Gaboury and Feduk (1996). Structures will be judged stable if they remain within 16.4 feet (5 meters) of their original location, their alignment has changed less than 20 degrees, anchor materials and connections are intact, and the LWD is sound with little rot, decay or fragmentation. The stability of each rehabilitation structure will be evaluated through field inspections conducted one, three and five years after construction. Performance criteria established in the HPA require that all structures must be able to withstand 100-year peak flows. To this end, Tacoma will also inspect the structures following all flow events with a return interval of 20 years or more as measured at Howard Hanson Dam.

Monitoring the total volume of LWD in the mainstem Green River and evaluating the effectiveness of LWD placement is beyond the scope of this compliance monitoring measure. Research funds are allocated to evaluate the effectiveness of woody debris placement as described in Chapter 6.3.

6.1.9 Compliance Monitoring Measure CMM-09 Mainstem Gravel Nourishment Monitoring

COMPLIANCE MONITORING MEASURE NUMBER: CMM-09

MEASURE: Mainstem Gravel Nourishment Monitoring

Tacoma will annually record the volume, type, location, and method of placement of gravel added to the Green River channel below the Headworks. Records will be maintained and made available to the Services on request. Tacoma's commitment under this conservation measure is limited to the contribution of funds necessary to place up to 3,900 yd^3 of gravel appropriately sized for use by spawning salmonids annually. Input sites will be inspected annually following high flows to identify the volume of gravel that has been redistributed downstream within the river channel.

Objective

Document that the required volume of gravel has been input to the Green River.

Rationale

The goal of the gravel nourishment conservation measure is to replace an increment of the bedload that was formerly delivered to the middle Green River but is now trapped behind Howard Hanson Dam. Records documenting the amount and composition of gravel input each year will be maintained to document that Tacoma is complying with the ITP. Monitoring the effectiveness of gravel nourishment is beyond the scope of this compliance monitoring measure. Research funds are allocated to evaluate the effectiveness of gravel nourishment as described in Chapter 6.3.

6.1.10 Compliance Monitoring Measure CMM-10 Upper Watershed Stream, Wetland, and Reservoir Shoreline Rehabilitation Monitoring

COMPLIANCE MONITORING MEASURE NUMBER: CMM-10

MEASURE: Upper Watershed Stream, Wetland, and Reservoir Shoreline Rehabilitation Monitoring

Habitat Rehabilitation

Structures installed as part of the Upper Watershed Stream, Wetland and Reservoir Shoreline Rehabilitation HCM will be monitored to ensure that they meet design criteria and remain stable. Final design criteria will be developed in cooperation with the Services, USACE, WDFW, and MIT during the preliminary engineering design

phase of the Additional Water Storage project. The goal of the criterion will be to achieve habitat indices equivalent to "good" ratings applied during Watershed Analysis (WFPB 1997), if applicable to the stream type, or by comparable criteria approved by the Services. The stability of the structures will be assessed using criteria based on the alignment, location, extent of fragmentation or decay, and condition of anchoring materials. The physical stability of the structures will be evaluated in years one, three and five following construction, and thereafter following all flows that have a return interval of 20 years as measured at HHD.

Structures that are deemed non-functional will be modified or replaced by Tacoma as needed within the first five years following construction. Tacoma will also fund one additional complete replacement within the term of the HCP should deterioration of the materials or flood damage make such an action necessary.

Vegetation in the Inundation Pool

Vegetation monitoring will occur through the use of randomly selected permanent transects and/or sample plots to identify vegetation cover and vigor. Vegetation sampling will be conducted in years 1, 3, 5, 7, and 10 following implementation of the AWS Project. If the percent cover does not meet the criteria summarized in Table 6-1 in any given year, Tacoma will re-plant as needed. If the percent cover of invasive non-native species increases over the existing conditions, Tacoma will implement a weed control treatment.

Fish Passage Barriers

The results of the culvert inventory will be presented to the Services within one year of issuance of the ITP, and a prioritized plan to eliminate artificial blockages in the upper HCP Area will be developed in cooperation with the Services, WDFW, MIT, and other landowners with property accessed by the affected roads within two years of issuance of the ITP. Stream crossings modified as part of the culvert improvements HCM will be sized to pass a 100-year flood flow and will meet culvert design criteria specified by the Washington Department of Fish and Wildlife (WDFW 1999) or comparable methodologies approved by the Services. Tacoma will provide documentation of the treatment date, hydrologic analysis, and design criteria used to treat each artificial blockage at the first five-year review. Should the new structures or existing passable structures become impassable during the term of the HCP, Tacoma will replace those structures within one year of identification, modifying the design criteria as necessary to reduce the risk of future blockages. Additional passage barriers treated after the initial reporting period will be summarized at the first five-year review following treatment. Identification of passage barriers that may form following the initial systematic inventory will be accomplished during the post-storm inspection program implemented under the Road Sediment Reduction Plan (RSRP).

Objective

Evaluate the physical condition and stability of rehabilitation structures to confirm that they meet design criteria, remain in place, and produce the desired hydraulic conditions.

Survey planted areas to confirm that the vegetative stocking and cover requirements are met. Confirm that management-related fish passage barriers have been corrected and that new passage structures meet design criteria.

Rationale

Habitat Rehabilitation. Design criteria for the upper watershed stream rehabilitation projects will be developed in cooperation with the Services, USACE, WDFW, and MIT during the PED Phase. Compliance with the design criteria will be documented by a one-time inspection of each rehabilitation site immediately following construction. The condition and stability of each structure will be assessed using general criteria developed by Gaboury and Feduk (1996). Structures will be judged stable if they remain within 16.4 feet (5 meters) of their original location, their alignment has changed less than 20 degrees, anchor materials and connections are intact, and the LWD is sound with little rot, decay or fragmentation. The stability of each rehabilitation structure will be evaluated through field inspections conducted one, three and five years after construction. Performance criteria established in the HPA require that all rehabilitation structures must be able to withstand 100-year peak flows. To this end, Tacoma will also inspect the structures following all flow events with a return interval of 20 years or more as measured at Howard Hanson Dam. If the structures fail to meet the stability criteria during the first five years, Tacoma will repair or replace them, modifying the design criteria as necessary in coordination with the Services. After the first five years, Tacoma will provide funding for one additional replacement of the structures, should they decay or fail following large floods.

A post-project completion report, describing any deviations from the original design, will be presented to the Services within six months after the project has been completed. The results of the initial stability inspections will be summarized in a report presented at the first five-year review. Additional inspection reports will be submitted at review periods during which a 20-year flow event has occurred.

Vegetation in the Inundation Pool. Monitoring of measures designed to establish inundation tolerant vegetation communities within the expanded inundation pool are intended to assess the rate and degree to which the desired plant community develops in newly submerged portions of the inundation pool. The Upper Watershed Rehabilitation HCM will be assumed to have effectively created the desired mix of floodplain forest and wetland communities if vegetation cover meets or exceed the criteria summarized in Table 6-1. If mortality exceeds the allowable percentages, the areas will be replanted after the reason for failure has been identified (e.g., poor planting stock; herbivory; hydrologic conditions). Following the establishment of plant materials, manual control,

or herbicidal treatment for control of non-native invasive species appropriate for the individual species will be developed as necessary.

Fish Passage Barriers. The goal of the culvert improvements HCM is to remove artificial barriers that prevent one or more lifestages of the covered species from moving up or downstream. The initial culvert inventory will be used to prioritize treatment of barriers; inventory results will be provided to the Services within one year and culverts, which require replacement, will be identified and prioritized in coordination with the Services, WDFW, MIT, and other landowners with property accessed by the affected roads within two years. Records of the treatments applied at each site, including the location, date of treatment, results of hydrologic analysis and physical specifications of the new structure (length, diameter, grade etc.) will be provided to the Services on request, and summarized for the first five-year review.

Watershed Analysis stipulates that a RSRP be developed for each watershed administrative unit within two years of final approval by the Department of Natural Resources. The RSRP requires landowners in the upper Green River to develop a program to inspect stream crossing sites with a high risk of failure, blockage or diversion following major storm events. Implementation of this post-storm monitoring will facilitate early identification of stream crossing sites where storm-related impacts that preclude fish passage may have occurred. If a previously passable culvert on Tacoma's land becomes impassable as a result of such impacts, Tacoma will replace the structure within one year of the initial identification. The results of ongoing culvert replacement or repair activities will be summarized for each five-year review.

6.1.11 Compliance Monitoring Measure CMM-11 Snowpack and Precipitation Monitoring

COMPLIANCE MONITORING MEASURE NUMBER: CMM-11

MEASURE: Snowpack and Precipitation Monitoring

To document that snowpack and precipitation monitoring stations have been installed and remain operational, Tacoma will ensure that the Services have access to the data on an internet homepage or an equivalent source consistent with advances in data transfer technology. Financial records documenting funds transfer will be provided to the Services on request.

Objective

Document compliance by making snowpack and precipitation monitoring data available to the Services and other interested parties.

Rationale

In order to improve the accuracy of water supply forecasting for the Green River, Tacoma is committing to providing funds for installation and annual maintenance of up to three snow pillows with rain gauges in the upper Green River basin. Snowpack data is downloaded from the snowpack telemetry (SNOTEL) sites by the National Resource Conservation Service on a daily basis between 1 November and 1 July and made available for use in water supply forecasting. Ensuring that snowpack and precipitation monitoring data from the new monitoring sites is available on an internet web page or comparable data transfer technology, and that records of financial contributions to the NRCS are available upon request will document that Tacoma has complied with the requirements of the snowpack monitoring HCM.

6.1.12 Compliance Monitoring Measure CMM-12 Upland Forest Management Monitoring

COMPLIANCE MONITORING MEASURE NUMBER: CMM-12

MEASURE: Upland Forest Management Monitoring

In coordination with the Services, Tacoma will place newly acquired forestlands it wishes to add to the HCP area in the upper watershed into one of the three forest management zones prior to initiating any management activities. At each scheduled reporting period, Tacoma will provide the Services with an updated map of the forest management zones and a table of current acreage totals (by zone). The map will show Tacoma ownership in the Upper HCP Area (above the Headworks) and distinguish between the three forest management zones.

A copy of the standard written notification provided to contractors and loggers notifying them of pertinent HCP measures and ensuring that they are aware of all relevant terms and conditions of the HCP will be provided to the Services at the first review in year 2. Updated copies will be provided at subsequent reporting periods if any changes are made to the notification.

At each scheduled reporting period, Tacoma will provide the Services with a current map of the three forest management zones showing the age of all forest stands in the Upper HCP Area and all stands that have been affected by timber harvest activities since the previous reporting period. The map will also depict the locations of sensitive habitats such as moderate to high hazard mass wasting map units (MWMUs), berry

fields, meadows, and ~~unforested talus fields larger than 0.5 acres~~**sites known to be occupied by covered species**.

Tacoma will provide a list of all forest management activities that have occurred in each forest management zone since the previous reporting period. The list will include the location (section, township, range), acreage, site index, type of harvest, active dates of harvest, method(s) of slash disposal and state Forest Practice Application number (if available) for all harvest activities, to document that the criteria summarized in Table 6-1 have been met. The results of any slope stability analysis required by watershed analysis prescriptions will also be included. Tacoma will report the results of post-harvest sampling to verify that leave-tree retention standards have been met. Regular reporting to the agencies will include listings of all hardwood conversion, and salvage timber harvest activities.

A summary list of all reforestation activities will be provided to the agencies at each scheduled review. The list will include the state Forest Practice Application number, date of planting, planting density and species of trees planted for all reforestation activities that have occurred since the previous reporting period.

Objective

Document additions to the Upper HCP Area; verify that forestry activities conducted in each of the three forest management zones comply with management restrictions; and verify snag, green recruitment tree, and log retention requirements have been met in the Upper HCP Area.

Rational

Lands owned by Tacoma in the Upper HCP Area are managed to protect water quality, provide habitat for fish and wildlife, and generate revenues through the harvest of timber to fund the overall land management program and finance the acquisition of additional lands in the watershed (Ryan 1996). The protection of water quality is the primary management objective throughout the watershed, but varying amounts of active management can occur to meet the other two objectives without compromising water quality. The amount of management that can occur in a given area is specified in the Upland Forest Management HCMs. The objective of this compliance monitoring measure is to document that the harvest and reforestation activities conducted in each of the three forest management zones comply with harvest restrictions, verify snag, green recruitment tree, and log retention requirements in the Upper HCP Area are met, and verify that harvest restrictions next to specialized habitats have been implemented.

6.1.13 Compliance Monitoring Measure CMM-13 Riparian Buffer Monitoring

COMPLIANCE MONITORING MEASURE NUMBER: CMM-13

MEASURE: Riparian Buffer Monitoring

Maps of riparian buffers will be prepared, and updated every five years. ~~In harvest units where the width of the natural zone adjacent to stream channels is less than 200 feet due to the presence of road or power line corridors,~~ **Riparian buffers will be measured and marked in the field prior to harvest to ensure that they meet criteria summarized in Table 6-1. Marking will be accomplished by measuring the width at least ten increments spaced at 100 feet or less.** Tacoma will ~~measure~~ **monitor** ~~the total width of~~ **each** riparian buffer immediately following harvest to ensure that **buffers have been left as marked.** ~~they meet the criteria summarized in Table 6-1. Surveys will consist of at least ten measurements spaced at increments of 100 feet or less.~~ The results of this monitoring will be provided to the Services at each five-year review.

Objective

Verify compliance with the riparian buffer requirements in the Upper HCP Area.

Rationale

Buffer strips are a common method for maintaining riparian system connection and function in the Northwest. Belt et al. (1992) reviewed over 100 documents that related riparian buffer strips to forest practices, water quality, and fish habitat. The provision of riparian buffer strips was correlated with stream water temperature, cover, large organic debris, and sediment production, all vital ingredients in the life history of salmonids. Johnson and Ryba (1992) found that the riparian zone stabilizes streambanks and prevents erosion, filters suspended sediment, moderates the microclimate, and supports and protects fish species. Riparian buffer areas also provide habitat conditions that are critical to many wildlife species (O'Connell et al. 1993). Thus, compliance with riparian buffer requirements in the Upper HCP Area becomes a critical element of both fish and wildlife management under this HCP.

In most cases, the width of the natural zone adjacent to the channel meets or exceeds minimum riparian buffer requirements. However, in some cases roads or powerline corridors are located within the RMZ, and define the outer limit of the natural zone. In addition, some of the smaller Type 3, 4, and 5 streams are located wholly or partially

within the conservation or commercial zones. On streams where the width of the adjacent natural zone is less than the minimum riparian buffer requirements, no-harvest and partial harvest buffers will extend into the conservation or commercial zone. In harvest units where riparian buffers are located wholly or partially within the commercial or conservation zones, Tacoma will **mark** ~~measure~~ the total width of no-harvest and partial harvest riparian buffers **prior to harvest** to ensure they meet criteria specified in this HCP. At least 10 measurements will be obtained at intervals of ≤100 feet to **delineate** ~~verify~~ the buffer widths. If the buffer zone is more than 1,000 feet long, measurements will be taken every 100 feet for the entire length of the buffer. **Tacoma will re-check buffers in the field following harvest to document that buffers have been left as marked.** ~~These~~ **Riparian monitoring** data will be summarized by stream type, and presented to the Services at each five-year review to document compliance.

6.1.14 Compliance Monitoring Measure CMM-14 Road Construction and Maintenance Monitoring

COMPLIANCE MONITORING MEASURE NUMBER: CMM-14

MEASURE: Road Construction and Maintenance Monitoring

Tacoma will document compliance with road management measures by regular reporting of road management activities. Maps depicting the location of all new roads, recently abandoned roads, active roads, and locked gates will be prepared, and updated at each scheduled reporting period. A table will be provided summarizing the characteristics of newly constructed roads including the road length, prism and drainage design, and surfacing. The total length of road abandoned within each reporting period, and a description of actions taken to abandon each road, will also be provided. A map depicting the location of roads relative to MWMUs with a moderate or high mass wasting potential identified during field inspections or through watershed analysis will be updated as necessary and presented at each five-year review. Maps, tables, and the results of any slope stability analyses conducted on new or existing roads as a requirement of watershed analysis will be presented to the Services at each five-year review.

A copy of the RSRP, annual updates (if needed), and results of any evaluation of the success in meeting sediment reduction targets required under watershed analysis prescriptions will be provided to the Services on request and summarized at five-year reviews

Objective

Verify that road management measures have been implemented as specified.

Rationale

Impacts to both fish and wildlife species have been attributed to the construction of roads (WDNR 1997). Roads have been responsible for triggering the majority of management-related landslides in the upper Green River basin (Reynolds 1996; Reynolds and Krogstad in prep). A positive correlation has been observed between the area of logging roads in a basin and levels of fine sediment in downstream spawning gravel (Cederholm et al. 1981). As the level of fine sediment in spawning gravel increases, survival of salmonid eggs and fry declines (Tappel and Bjornn 1983; Reiser and White 1988; Young et al. 1991). Both elk and deer habitat use increases with increasing distance from open roads (WDNR 1997). Thus, Tacoma will monitor roads within the Upper HCP Area to verify that road management measures have been implemented as specified in the HCP.

Periodic evaluation of road surface sediment contributions will be conducted as part of the five-year watershed analysis review process required by the WDNR. Completion of the five-year review is a cooperative effort between upper Green River watershed landowners. Documentation of Tacoma's participation in this process and copies of the RSRP, annual updates and five-year reviews will serve as evidence that Tacoma has complied with road management measures contained in this HCP.

6.1.15 Compliance Monitoring Measure CMM-15 Species-Specific Habitat Management Monitoring

COMPLIANCE MONITORING MEASURE NUMBER: CMM-15

MEASURE: Species-Specific Habitat Management Monitoring

Tacoma employees will receive instruction in the identification of covered species, and employees and contractors will be provided with a data sheet to be completed in the event that a covered species is sighted. Sightings by Tacoma employees or contractors will be reported to the Services and WDFW immediately. Tacoma will also obtain updated information from the WDFW priority habitats database and will provide written documentation that the WDFW and USFWS have been contacted to request information on recent sightings in the vicinity of the HCP area on an annual basis.

At each scheduled reporting period, Tacoma will provide maps depicting the location of newly constructed roads in relation to preferred grizzly bear habitats (berry fields, meadows, avalanche chutes, and wetlands) to verify that no new roads have been constructed through those habitats within the Upper HCP Area. If grizzly bear sightings are confirmed within the Green River watershed, Tacoma will summarize actions taken to comply with management restrictions listed in the species-specific HCMs at the next scheduled reporting period.

If gray wolf den sites are confirmed within the Green River watershed, Tacoma will summarize actions taken to limit activities within specified protection areas surrounding the den and rendezvous sites at each subsequent reporting period until the den site is confirmed to be no longer active. Similar summaries will be provided if Pacific fisher, California wolverine, or Canada lynx den sites are confirmed within the Upper HCP Area.

Seasonal and long-term protection measures will be implemented if peregrine falcon, bald eagle, spotted owl or northern goshawk nest sites are confirmed within the Upper HCP Area. Spotted owls are currently known to be present within the Green River watershed, including one nest site that is located within the Upper HCP Area. Tacoma will maintain records documenting that annual updates on the status of activity centers have been obtained, and will summarize actions taken to limit activity around the nest site at each scheduled five-year review. Similar documentation will be provided to the Services and WDFW if bald eagle, peregrine falcon, or northern goshawk nest sites are confirmed to be present within the Upper HCP Area.

Compliance with protection of trees and snags used by pileated woodpeckers or Vaux's swift will be reported as part of upland forest management monitoring. Compliance with the requirements for limiting ground disturbance and timber harvesting near potential Larch Mountain salamander habitat will also be demonstrated as part of upland forest management monitoring.

Objective

Verify compliance with species-specific management measures.

Rationale

Numerous threatened, endangered, or sensitive species may periodically use the Upper HCP Area. Among these, the following will receive special interest in this HCP: grizzly bear, Pacific fisher, California wolverine, Canada lynx, peregrine falcon, bald eagle, spotted owl, northern goshawk, pileated woodpecker, Vaux's swift, and Larch Mountain salamander. Compliance monitoring will demonstrate that Tacoma has taken steps to identify the status of the covered species in and near the HCP area, and has implemented species-specific HCMs as required.

Many of the conservation measures described in Chapter 5 have been developed to protect or enhance aquatic, wetland, or upland habitats or to address ecosystem functions such as sediment transport. These measures often benefit many of the species for which Tacoma is seeking coverage under the ITP. For example, Upland Forest Management Measures in the upper Green River basin will benefit fish and wildlife, and riparian plant communities. Where a species was not addressed by a specific conservation measure, general habitat conservation measures were considered to provide adequate protection.

Monitoring measures developed for general conservation measures are described elsewhere in this document.

6.2 Effectiveness Monitoring

A brief description of Effectiveness Monitoring Measures (EMMs), monitoring criteria, measurement frequency, reporting requirements, and contingencies are presented in Table 6-2. Tacoma's specific commitments associated with each measure are contained within a series of outlined textboxes that are presented following the table. The supporting rationale for each monitoring measure is also provided following individual textboxes. All monitoring activities will be summarized in writing and presented to the Services during reviews at five-year intervals. Individual monitoring measures may require more frequent reporting. Monitoring data will be maintained by Tacoma, and will be made available to the Services upon request.

The end result of effectiveness monitoring is to facilitate adaptations if the original measure proves inadequate. Detailed effectiveness monitoring criteria will be developed in cooperation with the Services. The results of effectiveness monitoring activities will be reviewed in coordination with the Services at five-year intervals, and if necessary, conservation measures that are judged to be ineffective will be modified. Effectiveness monitoring activities will continue until the Services are satisfied that the measures are achieving the desired resource objective. Funds required to implement effectiveness monitoring will be provided solely by Tacoma. Cost-reductions identified through increased efficiencies, competitive bids, or coordinated efforts with ongoing project operations will accrue to Tacoma.

Table 6-2. Effectiveness Monitoring to be Implemented under Tacoma's Green River HCP.

Measure	Description	Criteria	Measurement frequency	Reporting	Adaptive Management
EMM-01	Snag and Green Recruitment Tree Monitoring	• Rate of snag creation/retention meets the needs of the species covered by the ITP (see Chapter 2)	• Immediately following harvest and at 10-year intervals thereafter	• Data available to the Services on request • Cumulative results reported at 5-year reviews	• After year 10, adjust rate or method of intentional leave-tree mortality in coordination with the Services
EMM-02	Species-Specific Habitat Management Validation	• Document response of covered species to species-specific management measures	• As necessary, if species are present and specific management plans are implemented	• Summarize use of HCP area by covered species at 5-year reviews	• Modify measures as necessary in coordination with the Services
		• Review of response indicates that continuing management activities as prescribed in the species-specific management measure will not prevent continued use of the HCP area by the species	• Annually, as necessary, depending on presence of species	• Annual reporting to the Services until measure is determined to be effective	
EMM-03	**Uneven-Aged Harvest Monitoring and Adaptive Management**	• **Document if windthrow has resulted in individual stands containing an average of less than 25 healthy dominant or co-dominant conifers per acre 5 years after uneven-aged harvesting**	• **Five years after uneven-aged harvest operation**	• **The results of uneven-aged harvest monitoring conducted in the previous year will be reported as part of annual reviews**	• **Adjust the rate and/or method of harvesting**

6.2.1 Effectiveness Monitoring Measure EMM-01 Snag and Green Recruitment Tree Monitoring

MONITORING AND EVALUATION MEASURE: EMM-01

MEASURE: Snag and Green Recruitment Tree Monitoring

At ten-year intervals, Tacoma will revisit harvested areas (and adjacent riparian buffers and Upland Management Areas [UMAs]) to record the number, size, species, condition, and apparent wildlife use of snags and green recruitment trees left in compliance with the Snag and Green Recruitment Tree Habitat Conservation Measure. These data will be used to determine trends in snag retention, recruitment and use. If it is determined through review of Tacoma's data, or through reference to research conducted elsewhere in the Pacific Northwest that the rate at which Tacoma is killing green recruitment trees needs to be adjusted (up or down) to better meet the needs of the covered species, the Services will develop mutually-acceptable adjustments to the specified rate. However, in no case will there be changes to the rate within the first ten years of HCP implementation, as at least that much time is necessary to obtain a sample of sufficient size. The results of this monitoring will be reported at each five-year review.

Objective

Verify success of efforts to retain and recruit snags.

Rationale

Snags are important features of wildlife habitat that are frequently lacking or in short supply in intensively managed commercial forest lands. Given the overall management history of the Upper HCP Area, it is assumed that snag abundance is low. Snags will be allowed to develop through natural processes in the Natural Zone, in stands over 100 years old in the Conservation Zone, and in no-harvest riparian buffers and UMAs. However, in the Commercial Zone, and in stands less than 100 years old in the Conservation Zone, Tacoma may need to actively recruit snags at the time of harvesting by killing a portion of the green recruitment trees, as described in the Upland Forest Management HCMs. Snag creation is a relatively novel management tool, and monitoring is warranted to ensure that the overall objective of providing useable habitat for the covered species is met. Data will therefore be collected from harvested areas ten years after the harvest activities are completed and reviewed by the Services at regularly-scheduled reporting periods. Given the low rate of harvest anticipated under the HCP, a minimum of ten years will be necessary to collect sufficient data for a meaningful analysis. This amount of time will also be necessary to observe any meaningful changes in the number and condition of snags, since snag recruitment and decay are relatively

slow processes. For these reasons, there will be no revisions to the snag recruitment program for at least the first ten years of HCP implementation.

6.2.2 Effectiveness Monitoring Measure EMM-02 Species-Specific Habitat Management Validation

MONITORING AND EVALUATION MEASURE NUMBER: EMM-02

MEASURE: Species-Specific Habitat Management Validation

If the presence of a covered species is confirmed within the HCP area, Tacoma will implement species-specific management measures as described in Chapter 5, and will work with the Services to develop a monitoring program designed to assess the effectiveness of those measures. At each scheduled reporting period, Tacoma will provide available information on the responses of covered species to any of the species-specific management measures that have been implemented during the preceding period (e.g., nest or den site protection buffers or seasonal harvest activity restrictions).

In determining the need to adapt the species-specific conservation measures, it must be recognized that the measures are not intended to completely avoid impacts to covered species, nor are they intended to provide optimal habitat conditions for covered species in the HCP area. If continued management activities conducted in accordance with the prescribed species-specific measures are resulting in few direct impacts to the targeted covered species and do not prevent continued use of the overall HCP area by the species, the measures will not be adjusted. Conversely, if it is determined that continued management activities conducted in accordance with the prescribed measure are preventing use of the HCP area by a covered species, the measure will be adjusted. Adjustments to the species-specific management measures will be developed in coordination with the Services. The results of those adjustments will be evaluated and reported at subsequent five-year reviews until the Services are satisfied with the effectiveness of the conservation measures

Objective

Determine effectiveness of species-specific protection measures.

Rationale

The overall objective of the species-specific management measures in this HCP is to minimize the impacts of Tacoma's activities on various life stages of covered species. To that end, it is appropriate for Tacoma to review the effectiveness of these measures, and make adjustments that may be necessary to accomplish the overall objective. It is equally appropriate, however, to limit adjustments to those necessary to meet the overall

objectives of the HCP, and not necessarily to accommodate changes in public opinion or resource management policy.

6.2.3 Effectiveness Monitoring Measure EMM-03 Uneven-Aged Harvest Monitoring and Adaptive Management

MONITORING AND EVALUATION MEASURE NUMBER: EMM-03

MEASURE: Uneven-Aged Harvest Monitoring and Adaptive Management

Tacoma will evaluate the success of uneven-aged harvesting in the Conservation Zone by revisiting harvested stands five years after each uneven-aged harvest operation. Tacoma will determine the number of standing live overstory trees after five years, the conditions of the standing live trees, the number and size of standing snags, and (if possible) the mechanism responsible for the falling of overstory trees and snags left at the time of uneven-aged harvesting. Tacoma will also make qualitative assessments of understory shrub and forb development five years after harvesting.

If windthrow has resulted in individual stands containing an average of less than 25 healthy dominant or co-dominant conifers per acre five years after uneven-aged harvesting. Tacoma will consider that cause to adjust the rate and/or method of harvesting. Before adjustments are made, however, factors such as aspect, slope, position on slope, soil moisture, and overstory species composition will be evaluated. Adjustments to the rate and/or method of harvesting will only be made in those locations where comparable high rates of windthrow can be expected.

Tacoma and the Services will also keep abreast of research elsewhere in the region on the methods and effects of uneven-aged harvesting, particularly such harvesting with the intention of producing late-seral forest habitat for wildlife. The rate and/or method of uneven-aged harvesting on the Covered Lands will be modified if Tacoma and the Services agree that research suggests the need for a change. Research can suggest a change if it is found that the method and/or rate in the HCP is counter to the objective of accelerating the development of late seral forest conditions and that it is detrimental to the maintenance of habitat for one or more of the Covered Species, or that it conflicts with the protection of individuals of a Covered Species.

Objective

Evaluate the success of uneven-aged harvesting, and adjust the method and/or rate of harvesting, when necessary, to accelerate the development of late-seral coniferous forest conditions.

Rationale

Uneven-aged managed through selection harvest and commercial thinning has been suggested as a means of accelerating the development of late-seral coniferous forest conditions in young managed forests (Carey 1994). Thinning can be problematic; however, because it can lead to increased windthrow among the remaining overstory trees (Stathers et al. 1994), it can retard stand development. Wind is a prevalent problem on the west slopes of the Cascade Mountains, but the effects of wind on overstory trees tend to be somewhat correlated with site-specific conditions (Tang 1995). Most damaging winds come from the south and southwest, making trees on slopes facing those directions most vulnerable. Trees on exposed upper slopes and ridge tops are more vulnerable than trees in protected valley bottoms. Soil moisture can affect susceptibility; wetter soils result in trees with shallower roots that are less stable and more vulnerable to being blown over. The species of tree is also a factor, since some species are characteristically more shallow-rooted than others. Lastly, the history of an individual tree affects its vulnerability to wind. Trees that grow in the open are exposed to wind throughout their lives and develop more extensive root systems to support their larger boles and crowns. Conversely, trees that develop in dense stands typically have narrower stems and less extensive root systems. When these trees are suddenly exposed to increased winds as a result of thinning or selection harvest, they experience increased rates of windthrow.

Tacoma will consider all site-specific conditions when planning commercial thinning operations, and thinning will not occur on sites considered particularly susceptible to windthrow. As an additional precaution, thinned stands will be visited five years after thinning to assess windthrow.

While a certain level of windthrow is natural and desirable for creating late-seral forest conditions, excessive windthrow is not. A threshold of 25 dominant or co-dominant surviving conifers is considered appropriate for the HCP, since stands of this density still have sufficient live trees to develop late-seral forest characteristics (Franklin et al. 1981). An analysis period of five years was chosen because it is believed that if windthrow is going to be excessive, it will appear within the first five years after harvesting. After that time, the combination of increased canopy density (from growth of individual crowns) and increased wind firmness of individual trees (from root and stem development) will decrease the potential for windthrow.

Tacoma and the Services will also review pertinent research in the region on the effects of commercial thinning. If such research suggests the need to change the thinning program in the HCP, Tacoma and the Services will consider such changes. Changes will be made primarily where they will assist in achieving the overall objective for the Conservation Zone (developing and protecting late-seral coniferous forest), but changes may also be considered to accomplish other objectives that do not conflict with the primary objective (e.g., reducing HCP implementation costs).

6.3 Research

The Research Funding Measures (RFMs), measurement frequency, reporting requirements, objectives, and contingencies are summarized in Table 6-3. Tacoma's specific commitments associated with each measure are contained within a series of outlined textboxes that are presented following the table. The supporting rationale for each measure is also provided following individual textboxes. Additional details of the research program will be developed in coordination with the NMFS and USFWS, the USACE and the Green River Flow Management Committee during the preliminary engineering and design phase of the AWS project. The USACE and Tacoma may modify the research program, in coordination with the Green River Flow Management Committee, provided the NMFS and USFWS concur.

Based on the results of the research, Tacoma may modify implementation of the HCP, if requested by the NMFS and USFWS. Tacoma may also modify implementation of the HCP, if requested by the NMFS and USFWS, based on the consensus of the USACE and the Green River Flow Management Committee. Any such modifications made by Tacoma shall not represent additional commitments of money, water, or other resources without the consent of Tacoma. All research activities will be summarized in writing and presented to the Services during reviews at five-year intervals. Individual measures may require more frequent reporting. Research data will be maintained by Tacoma, and will be made available to the Services upon request.

Funding of the research measures is described in Chapter 8 of this HCP. As described in Chapter 8, Tacoma will provide funds solely or in conjunction with other entities. Cost-savings identified through increased efficiencies, competitive bids, or coordinated efforts with other monitoring programs (e.g., King County restoration efforts) will accrue to the Green River research fund. Increased funding of specific research measures must be provided through cost-savings from other RMs or must come from sources other than the City of Tacoma.

Table 6-3. Tacoma's Green River HCP commitments in support of Research.

Measure	Description	Measurement frequency	AWSP Project Years	Reporting	Objective	Contingency
RFM-01 HHD Downstream Fish Passage Research	**A. Monitor movement of juvenile fish into reservoir**					
	Seasonal installation of fyke net in upper mainstem	2 days per week	1-9 years between years 6 and 10	Results will be reviewed annually for minor modifications and reported at the 5-year reviews	Identify species, timing, size and age distribution of fish migrating downstream into Howard Hanson Reservoir	GRFMC to recommend changes to timing and rate of storage/release regime
	B. Monitor reservoir passage of juvenile fish					
	Conduct mobile hydroacoustics surveys of Howard Hanson Reservoir (e.g., USFWS 1993)	Weekly	2, 3, 5, 10	Results will be reviewed annually for minor modifications and reported at the 5-year reviews	Determine fish distribution throughout the reservoir during the peak downstream migration period	GRFMC to recommend changes to timing and rate of storage/release regime
	C. Monitor reservoir passage and survival, fish passage facility survival and fish collection efficiency					
	Paired PIT tag releases and detection	Sample size and replications to be determined during PED phase	1, 2, 5, 10	Results will be reviewed annually for minor modifications and reported at the 5-year reviews	Provide data on reservoir and project passage efficiency and survival	USACE changes to MIS facility, GRFMC to recommend changes to timing and rate of storage/release

Table 6-3. Tacoma's Green River HCP commitments in support of Research.

Measure	Description	Measurement frequency	AWSP Project Years	Reporting	Objective	Contingency
Downstream Fish Passage Research (cont.)	**Seasonal operation of screw trap at the outlet of HHD but upstream of fish bypass outfall**	**Sampling protocol to be determined during PED phase**	**3, 4, 5, 10**	**Results will be reviewed annually and reported at the 5-year reviews**	**Provide data on project passage efficiency and survival**	**GRFMC to recommend changes in MIS operation and changes to timing and rate of storage/release regime**
	D. Monitor condition of fish passing through fish passage facility					
	Sampling station upstream of the outfall will allow assessment of fish condition, and supplemental tagging. Fish assessment will include: • species, number and age; • injury and/or mortality; • length, weight; and • smoltification	Sampling protocol to be determined during PED phase	Annually in years 1-10	Results will be reviewed annually for minor modifications and reported at the 5-year reviews	Provide data on reservoir and project passage efficiency and survival	USACE changes to MIS facility, fisheries agencies to recommend changes to restoration strategy
	E. Marked Fry					
	Mark and recapture juvenile salmonids to quantify capture efficiency of sampling station	Sampling protocol to be determined during PED phase	1,2,3	Results will be reviewed annually for minor modifications and reported at the 5-year reviews	Quantify efficiency of MIS screen and fish bypass facility	USACE changes to MIS facility, GRFMC changes to timing/rate of storage/release

Table 6-3. Tacoma's Green River HCP commitments in support of Research.

Measure	Description	Measurement frequency	AWSP Project Years	Reporting	Objective	Contingency
Downstream Fish Passage Research (cont.)	**F. Hydroacoustic surveys**					
	Fixed hydroacoustics deployed in HHD forebay, fish passage facility horn, and wetwell. Mobile hydroacoustic monitoring and gillnetting in reservoir. Placement of transducers in the passage facility	Sampling protocol to be determined during PED phase	1, 2, 3, 4, 5, 10	Results will be reviewed annually for minor modifications and reported at the 5-year reviews	Determine whether juvenile fish can find and use the bypass system	USACE changes to MIS facility, GRFMC changes to timing and rate of storage/release
	G. Monitor water quality and zooplankton in the reservoir					
	Spring and summer surveys in upper and lower portions of the reservoir	Sampling protocol to be determined during PED phase	1, 5, 10	Results will be reported at the 5-ear reviews	Identify gross changes in reservoir productivity and salmonid feeding habitats that occur as a result of implementing the AWSP	Fisheries agencies to recommend changes to restoration strategy
	H. Monitor Predator Abundance in the Reservoir					
	Snorkel surveys to identify concentrations of predatory fish at migratory transition areas (reservoir confluences, outfalls), hook and line or nets to collect stomach samples	Sampling protocol to be determined during PED phase	3, 5, 10	Results will be reviewed annually for minor modifications and reported at the 5-year reviews	Compare the effects of the AWS on predator populations and consumption rates	Fisheries agencies to recommend predator control program

Table 6-3. Tacoma's Green River HCP commitments in support of Research.

Measure	Description	Measurement frequency	AWSP Project Years	Reporting	Objective	Contingency
RFM-02 Flow Management Research	**A. Monitor effectiveness of flow management strategies on side channel habitats**					
	Physical habitat Quantify inlet/outlet elevations and LWD; map habitat at various flows	Survey every two weeks February-June	1, 4, 10 and every 5 years (11-50)	Results reviewed annually for minor flow changes and reported at first 5-year review	Provide data on side channel connectivity and the quality and quantity of habitat provided by various flow release schedules	GRFMC to recommend changes to timing and rate of storage/release regime
	Biological Conduct snorkel and electrofishing surveys to identify timing of emergence, distribution, growth, and response to flow changes	Survey every two weeks February-June	2, 5, 10 and every 5 years (11-50)	Results reviewed annually for minor flow changes and reported at first 5-year review	Evaluate the biological response to flow management to guide development of a flow management strategy	GRFMC to recommend changes to timing and rate of storage/release regime
	B. Monitor steelhead spawning and incubation Contribute funding to the MIT and WDFW to conduct steelhead spawner surveys	Every 7-10 days April-July	Annually years 1-50	Results reviewed annually for minor flow changes and reported at first 5-year review	Evaluate the effects of the released flows on steelhead spawning and egg incubation	GRFMC to recommend changes to timing and rate of storage/release regime

Table 6-3. Tacoma's Green River HCP commitments in support of Research.

Measure	Description	Measurement frequency	AWSP Project Years	Reporting	Objective	Contingency
Flow Management Research (cont.)	**C. Monitor downstream migration of juvenile salmonids** Install and operate rotary screw trap near RM 34 to monitor mainstem juvenile movement	Four evenings and one 24-hour sample per week from February-June	1, 2, 3, 4, 5, 10 2 years out of every 10 (11-50)	Results will be reviewed annually to suggest minor modifications and reported at the first 5-year review	Identify changes in juvenile salmonid downstream migration patterns resulting from implementation of the AWS project	GRFMC to recommend changes to timing and rate of storage/release regime
	D. Monitor salmon spawning and Incubation (WDFW/MIT) Provide financial support to WDFW/MIT to expand spawning surveys to lateral habitats and restoration sites	Every 10 days September-November	1, 2, 3, 4, 5 and reduced annual effort years 6-50	Results will be reviewed annually to suggest minor modifications and reported at the 5-year review	Identify off channel habitats used by salmonids that are affected by an early refill schedule	GRFMC to recommend changes to timing and rate of storage/release regime
	E. Monitor salmon redds and emergence (MIT/WDFW) Identify salmon redds during spawning season and monitor impacts of early refill using fry emergence traps	Install traps January-February	1, 2, 3,	Results will be reviewed annually to suggest minor modifications and reported at the 5-year review	Evaluate the impact of early refill on salmon emergence and incubation	GRFMC to recommend changes to timing and rate of storage/release regime

Table 6-3. Tacoma's Green River HCP commitments in support of Research.

Measure	Description	Measurement frequency	AWSP Project Years	Reporting	Objective	Contingency
RFM-03 Sediment and Woody Debris Research	**A. Monitor distribution of woody debris** Survey Green River from Headworks to Highway 18 to identify distribution and abundance of woody debris	One survey during early spring to identify woody debris abundance and distribution	1, 2, 3, 4, 5, and 10	Distribution of woody debris to be provided to GRFMC following surveys. Results will be reviewed annually; reported to the Services at year 5 and 10 reviews	Provide data to the NMFS, USFWS, USACE, and the GRFMC that will facilitate an evaluation of the wood debris management program to restore woody debris recruitment and function in the Green River without compromising public health and safety or the viability of downstream flood control measures	Change location and method of placement; within costs of transporting and dumping LWD and five trucks of SWD
	B. Monitor distribution of sediments below Tacoma Headworks • Areal extent of gravel bars exposed at flow < 300 cfs at Auburn gage • Changes in bed elevation and channel capacity at selected cross-sections	One measurement during low flow conditions each year	1, 2, 5, 10	Results will be reviewed after annual surveys to suggest changes in placement method and location; reported to the Services at 5-year reviews	Provide data to NMFS, USFWS, USACE, and the GRFMC that will facilitate an evaluation of gravel nourishment activities in the middle Green River	Change location and method of placement; within costs of 3,900 yd^3 at Flaming Geyser

6.3.1 Research Funding Measure RFM-01 (A-H) HHD Downstream Fish Passage Facility

RESEARCH FUNDING MEASURE NUMBER: RFM-01(A-H)

MEASURE: HHD Downstream Fish Passage Facility

Because of the size and the complexity of the fish passage facility, monitoring and evaluation of the HHD downstream fish passage facility will be segregated into the following categories: fish migration into the reservoir (RFM-01A), reservoir passage of juvenile fish (RFM-01B); reservoir passage survival, fish passage facility survival and fish collection efficiency (RFM-01C); condition of fish passing through collector passage (RFM-01D); marked fry (RFM-01E), hydroacoustic surveys (RFM-01F); reservoir water quality monitoring (RFM-06G), and reservoir predator abundance monitoring (RFM-01H). Data from these studies will be provided to the Green River Flow Management Committee (GRFMC) as needed to make decisions regarding minor annual modifications to the storage and release schedule. The results of the studies will be presented at regularly scheduled five-year reviews to facilitate an evaluation of the effectiveness of the HHD downstream passage facility and to aid in making adaptive management decisions.

RFM-01A: Monitor Movement of Juvenile Fish into Reservoir

Tacoma will contribute funding to operate a fish trap (i.e., fyke net) at the confluence of the North Fork and mainstem Green River to characterize the immigration of juvenile salmonids into the reservoir. This activity will include a weekly evaluation (of two days per week) of immigration timing of juvenile fish entering the reservoir. The species, size, and age of each fish trapped will be recorded. Stomach contents will also be collected from a sub-sample of the fish. In addition to planned weekly evaluations, sampled fish will be marked and evaluated at the outfall sampling station in conjunction with other study components, such as paired PIT-tag release and recapture, assessment of the MIS and fish passage facility efficiency, and hydroacoustic monitoring of the forebay and wetwell. Monitoring will be conducted in project years 1, 2, 3, 4, 5 and every two years between years 6-10. It is recommended that monitoring continue two years out of every 10 years between years 11 and year 50; however, funding for monitoring past year 10 will not be part of Tacoma's obligations under this HCP.

RFM-01B: Monitor Reservoir Passage of Juvenile Fish

Tacoma will contribute funding to PIT-tag (passive-integrated transponder), release, and monitor coho, chinook, and steelhead smolts in project years 2, 3, 5, and 10.

Final numbers of tagged fish of each species will be determined through agency coordination and discussion with a statistician. Tagged fish will be supplied from a mutually agreed-to hatchery/smolt rearing facility or capture process as determined by MIT, WDFW, and NMFS. Two or more release locations will be situated upstream of the fish bypass facility, to include releases at the forebay and 0 to 0.5 miles upstream of the reservoir at various pool levels. Release groups will include simultaneous (at

both release locations), systematic releases of each species, and will be spread out over a three to four week period. Release times will bracket the peak outmigration period for steelhead, coho, and chinook. Tagged fish will be monitored downstream of the modular-inclined screen (MIS) near the bypass outfall. Information gained during reservoir passage monitoring will be provided to the Green River Flow Management Committee annually for use in making minor modifications to reservoir refill strategies. The results of the study will be evaluated and presented at the five-year reviews to determine whether major changes to the storage/release regime are warranted.

RFM-01C: Monitor ~~Reservoir Passage Survival~~, Fish Passage Facility Survival, and Fish Collection Efficiency

Tacoma will contribute funding to monitor the efficiency of the MIS and the fish bypass facility during normal juvenile outmigration times in project years 1 through 10. Three groups of coho salmon, chinook salmon, or steelhead fry will be released to test the efficiency (injury rate and survival) of the MIS screen and fish bypass facility. The final number of replications, and number of marked fish required for each replication, will be determined through agency coordination and discussion with a statistician. Marked fish will come from a mutually agreed-to hatchery/supplementation facility as determined by MIT, WDFW, and NMFS. Three release locations will be used including: upstream of the fish passage facility (either above the trashrack or at the entrance to the facility); below the MIS screen in the bypass flume; and at or below the wetwell exit. One test group will be used to evaluate MIS efficiency; another test group will be used to evaluate the bypass system; and a third test group will be used to evaluate the wetwell exit and bypass flume. Test fish will be recovered at the sampling station located approximately 100 feet upstream of the bypass outfall.

In addition, the bypass and screen are currently proposed to have viewing portals so an observer can look directly at the screen. The MIS surface will be periodically monitored at various flow rates and velocities to assess impingement of smolts against the MIS. Information collected through this monitoring activity will be presented to the USACE to guide development of modifications to the fish passage facility collection system if such actions are deemed necessary by the Services.

Salmonids moving downstream from the upper Green River watershed will pass downstream through the HHD project through either the new intake tower and MIS, or through the existing radial gates. Monitoring the number, species and condition of fish passing through the existing radial will be addressed through operation of a screw trap in the mainstem Green River channel immediately below HHD. A screw trap will be operated during the spring outmigration season below the HHD outlet but upstream of the fish bypass outfall. The results of the screw trap will be used to identify the number, species, and conditions of fish passing through the radial gates during periods of reservoir storage. Operation of the screw trap will also enable researchers to identify project operations that may allow juvenile salmonids to bypass the MIS and counting station and egress through the radial gates. A screw trap will be operated during years 3, 4, 5, and 10 following completion of the AWS project. Results will be reviewed annually and at the five-year reviews.

RFM-01D: Monitor Condition of Fish Passing Through Fish Passage Facility

Tacoma will contribute funding in project years 1 through 10 to monitor the condition (injury, mortality, length, weight, smoltification, and stress) of test and natural outmigrants after the fish pass through the bypass system, are locked through the wetwell, and released through the discharge flume of the HHD fish passage facility. A sampling station will be built near the fish bypass outfall. The sampling station will be used for assessment of marked (fin-clipped and PIT-tagged) and unmarked separate outmigrants. The sampling station will include a separation system that includes PIT-tag monitors, adjustable slide gate, and double read firmware to keep marked from unmarked fish. Sampling station facilities located next to the bypass outfall will include: flume from juvenile bypass to the sampling station; water supply separate from diverted bypass flume; holding tanks or troughs for diverted fish; and a secondary flume to return sampled fish to the Green River.

Marked juveniles and smolts will be analyzed to determine travel time, reservoir survival, and fish passage efficiency at HHD. Unmarked smolts, in conjunction with hydroacoustic monitoring, will be used to determine species composition of outmigrating fish.

Species, growth characteristics, and injury rates will be recorded for each fish. The sampling protocol will consist of a weekly evaluation (two to three hours per day, every other day) during the juvenile salmonid outmigration period. In addition to the planned weekly evaluations of fish condition and species composition, the sampling station will support other study components such as reservoir passage, assessment of the fish passage facility efficiency, and hydroacoustic surveys.

RFM-01E: Marked Fry

Tacoma will contribute funding to test the efficiency of the MIS and fish bypass facility using controlled releases of marked groups of juvenile salmonids. A series of releases of marked chinook, coho, and steelhead juveniles will be conducted during the juvenile salmonid outmigration period. The sample size and number of test releases will be identified during discussions with an experienced biometrician, resource agencies, and the MIT. Tests will be conducted in years 1, 2, and 3.

RFM-01F: Hydroacoustic Surveys

Tacoma will contribute funding to monitor the number and location of juvenile and adult salmonids in the forebay, the number and behavior of fish entering the fish lock, and the diel and seasonal distribution (horizontal and vertical) of juvenile and adult salmonids in the reservoir in years 1 through 5 and year 10. These study elements shall be monitored using hydroacoustic surveys. A scanning system for the tracking of fish in the forebay will include a hydroacoustic system with one or two split-beam transducers. Forebay hydroacoustic monitoring will be used to assess the utility of flow management (i.e., ramp-up and ramp-down events) to attract juvenile fish to the fish passage facility. The information gained from mobile hydroacoustic surveys will be used to evaluate total project survival of juvenile migrants, predator build-up at tributary confluences, and congregations of juvenile outmigrants upstream of the passage facility.

Transducers will also be placed at various locations within the passage facility. Transducers placed downstream of the trashracks will provide entrainment estimates for the fish collector and radial gates. Additional transducers will be placed near the wetwell exit and lock chamber. The facility, as now planned, would have an automatic control that regularly cycles lock events at pre-programmed times. The linked control to the hydroacoustics would be biologically based, giving estimates of fish density in the lock chamber before a lock event occurs.

RFM-01G: Monitor Water Quality and Zooplankton in the Reservoir

Tacoma will contribute funding to establish three permanent water quality stations to monitor the water temperature, DO, and conductivity in Howard Hanson Reservoir. In addition, surveys will be conducted in years 1, 5, and 10 to collect zooplankton data in the upper and lower sections of the reservoir for analysis. This data will be analyzed in conjunction with stomach contents collected during the juvenile salmonid reservoir migration study. Data from the zooplankton surveys will be used to assess changes in the overall composition of the invertebrate community (distribution and densities). Used in combination with other sampling data and mobile-hydroacoustic surveys, water quality surveys will further the knowledge of juvenile salmonid ecology in the reservoir and will be provided to the NMFS, USFWS, WDFW, and MIT in part to assess the influence of water management procedures on prey abundance.

RFM-01H: Monitor Predator Abundance in the Reservoir

Tacoma will contribute funding to monitor the distribution and abundance of trout and other predators of juvenile anadromous salmonids in Howard Hanson Reservoir and in the vicinity of the HHD and Headworks bypass outfalls in order to compare the effects of the AWS project on predator populations and consumption rates. Two years of monitoring of resident trout and/or avian predator abundance in the reservoir will be conducted prior to initial operation of the HHD downstream fish passage facility, followed by post-construction monitoring in project years 3, 5, and 10. It is recommended that additional monitoring be conducted every five years during project years 11-50; however, funding in years 11-50 will not be part of Tacoma's obligations under this HCP. Specific details of the monitoring methodology will be developed during the PED phase, and submitted to the Services for approval prior to implementation. If an increase in overall predator abundance in response to juvenile migratory presence is detected, a selective predator removal program may be initiated. However, such a program would only be initiated if recommended by the NMFS, USFWS, WDFS, and MIT.

Objective

RFM-01A - Identify species, timing, size and age distribution of fish migrating downstream into Howard Hanson Reservoir.

RFM-01B - Determine fish distribution throughout the reservoir during the peak downstream migration period.

RFM-01C - Provide data on reservoir and project passage efficiency and survival.

RFM-01D - Provide data on reservoir and project passage efficiency and survival.

RFM-01E - Quantify efficiency of modular inclined screen (MIS) and fish bypass facility.

RFM-01F - Determine whether juvenile fish can find and use the bypass system.

RFM-01G - Identify gross changes in reservoir productivity and salmonid feeding habitats that occur as a result of implementing the AWS project.

RFM-01H - Compare the effects of the AWS project on predator populations and consumption rates.

Rationale

The use of state-of-the-art fish passage technology and the complexity of the HHD project operations will require an extensive, long-term research program to provide feedback to maximize benefits to outmigrating juvenile salmonids. Such a program is needed to identify optimal facility and reservoir operations that will likely need to be adjusted based on water year type (i.e., wet, normal, or dry), and as the composition of fish stocks changes upstream of HHD. Information gathered as part of this research program will be provided to the GRFMC, agencies responsible for making decisions regarding fisheries management, and to the USACE as necessary to guide adaptive management of the downstream passage facility.

Monitor Movement of Juvenile Fish into Reservoir. Like other HHD downstream fish passage monitoring activities, monitoring the migration of fish into the reservoir is a critical step in evaluating the success of reintroducing anadromous salmonid populations above HHD. Dilley and Wunderlich (1992, 1993) successfully trapped juvenile salmonids in both the North Fork and mainstem of the Green River upstream of the full-pool mark. They determined trends, rather than quantitative estimates of fish movement, that, when compared to hydroacoustics, helped them (or will help others) to understand fish passage through the reservoir. Monitoring fish migration into the reservoir is important to determine if juvenile fish migrations are delayed and if that delay is attributable to the AWS project.

Monitor Reservoir Passage of Juvenile Fish. Beginning in 1991, the USFWS performed a series of studies to evaluate the downstream passage of fish at HHD (Dilley and Wunderlich 1992, 1993; Dilley 1993, 1994; Aitkin et al. 1996). Outmigration study results indicated that increasing outflow from HHD during periods of high inflow will increase the number of smolts that can safely exit the project during the smolt migration period (Dilley and Wunderlich 1992, 1993). In addition to the USFWS studies, in 1984

WDFW trapped smolts at the existing radial gate outlet (Seiler and Neuhauser 1985). The results of these studies were incorporated into the design process and used by the HHD Fish Passage Technical Committee (FPTC) for evaluating alternative designs of HHD outlet facilities (e.g., MIS, fish bypass, and fish lock), and spring refill rule curves.

PIT-tags can be used for the large-scale marking of fry to smolt-sized fish (55-65 mm and larger). Tags can be used to assess reservoir survival, overall fish passage efficiency and timing of entrance into the HHD fish passage facility during refill and high pool (Prentice et al. 1990; Peterson et al. 1994). PIT-tags provide an individual tag number of each marked fish and, when passed through the excitation field of the antennae, provide an immediate return on arrival time of that marked fish at the fish passage facility. PIT-tags can be used to activate fish separation facilities so that marked fish can be automatically diverted to a sampling station. PIT-tags may also be used in combination with coded-wire tags (CWT) during outplants of fry in the upper Green River so that fry-to-smolt survival can be assessed and used for evaluation of overall success of the HHD fish bypass project (Peterson et al. 1994; Achord et al. 1996).

Monitor Reservoir Passage and Survival, Fish Passage Facility Survival, and Fish Collection Efficiency. Although the MIS screen is considered state-of-the-art technology, a test of the MIS installed at the fish passage facility will be necessary to ensure that the MIS screen meets design criteria (Smith 1993; Taft et al. 1993; Winchell et al. 1993; Taft et al. 1997). As with the monitoring measure intended to track movement of juvenile fish through the reservoir, PIT tags are considered the best tool for evaluating passage of fish through the fish passage facility. Passage of juvenile fish through the collector and fish passage facility will be evaluated using the following methodology, or comparable methodologies approved by the Services.

The PIT-tag monitoring system will include:

- One portable PIT-tagging station for tagging fry and/or smolts in the hatchery or field: electronic balance, digitizer, tag detector, automatic tag injector, multi-port controller, laptop, or other portable computer.
- Two or three PIT-tag extended range fish monitors. One monitor will be located at the beginning of the juvenile bypass system while the second will be located near the bypass outfall.

Tagged fish will be monitored by a two- or three-coil system (24 in, 134.2 KHz tunnel monitor with estimated 90-95 percent detection probability, or best available technology) located downstream of the modular-inclined screen (MIS) near the bypass outfall.

A separation system for PIT-tagged fish within the bypass flowline will be installed. Once a fish monitor detects a PIT-tag, a controller will activate a trigger mechanism that opens a slide gate to separate the tagged fish from the juvenile bypass flume, into a secondary flume, and into holding tanks in the sampling station (described below). Components will include an adjustable slide gate and double-read firmware.

Monitor Condition of Fish Passing Through Fish Passage Facility. Monitoring of the condition of fish passing through the fish passage facility is needed to fully evaluate its overall efficacy. Data will be provided to the USACE, NMFS, USFWS, and WDFW for review, and they will recommend changes to the MIS facility or restoration strategy if necessary. This measure will also help determine the composition of fish that exit the facility and ensure that the fish bypass facility meets the desired biological criteria.

Marked Fry. Although laboratory tests and tests at other sites in the Pacific Northwest have shown juvenile salmonid survival rates exceeding 95 percent, the modular inclined screen (MIS) is considered experimental technology, (Smith 1993, Taft et al. 1993, Hilgert et al. 1997). Marked groups of juvenile salmonids will be released to test the efficiency of the MIS and fish bypass facility. Data will be provided to the USACE, NMFS, USFWS, and WDFW for review, and they will recommend changes to the MIS facility or restoration strategy if necessary.

Hydroacoustic Surveys. Hydroacoustic surveys are needed in order to evaluate fish distributions at the dam, forebay, and near the fish passage facility under varying flow and reservoir elevation conditions. Fish densities and trajectories can be quickly mapped over relatively large areas using a combination of target tracking and stepped-scanning hydroacoustic techniques (Thorne 1992). A split-beam transducer on a dual-axis rotator can continuously sample the forebay area and near the intake horn for the presence of downstream-migrating juveniles and larger fish (potential predators). Dilley and Wunderlich (1992, 1993) conducted hydroacoustic monitoring (single beam) of smolt outmigration through the existing bypass and radial gate outlets at HHD. Hydroacoustic monitoring was successfully used in conjunction with scoop-trapping below the outlet to determine the daily passage rates of downstream-migrating coho and chinook salmon juveniles and smolts through the dam. Dilley (1994) was able to characterize the diel and seasonal horizontal and vertical distribution of juvenile and adult anadromous and resident salmonids in the reservoir using mobile hydroacoustic equipment and gill net surveys. Hydroacoustic monitoring is important to determine if juvenile salmonids can find and use the fish bypass entrance.

The proposed monitoring program will include a scanning system for the tracking of fish in the forebay, including a hydroacoustic system with one or two 6 by 10° elliptical split-beam transducers with rotators. Transducers and rotators may be mounted on the trashrack and will require power and data transmission cable connections. System components for the evaluation for outmigrant juvenile anadromous salmonids through HHD include:

- two 6 by 10° split-beam transducers placed downstream of the trashracks;
- one 6° conical transducer with rotator placed in the wetwell exit;
- two 6 by 10° transducers placed in the lock chamber;
- two spare transducers and cable for replacement/back-ups; and
- one mobile hydroacoustic unit to monitor and evaluate outmigrant juvenile anadromous salmonids and larger salmonids at various locations around the facility.

Transducers placed downstream of the trashracks will provide entrainment estimates for the fish collector and radial gates. Additional transducers will be placed near the wetwell exit and lock chamber. The facility, as now planned, would have an automatic control that regularly cycles lock events at pre-programmed times. The linked control to the hydroacoustics would be biologically based, giving estimates of fish density in the lock chamber required before a lock event occurs.

Monitor Water Quality and Zooplankton in the Reservoir. Currently, the USACE conducts semi-monthly water quality surveys within the reservoir, concentrating on temperature, DO, and conductivity at specific depths. This monitoring measure will provide supplemental data on important water quality characteristics at selected locations in the reservoir. The reservoir will be undergoing dynamic changes during the initial years of the AWS project. Changes that may result from the AWS project include: a large influx of nutrients from inundation of surrounding vegetation; an increase in heat budget and development of a more pronounced thermocline; re-introduction of salmon carcasses and resulting increase in nutrients; and increased densities of juvenile salmonids. Any of the aforementioned events may result in changes to the migration pattern of juvenile salmonids moving through HHD. This measure will track any changes in water quality that may affect juvenile salmonid migrations through the reservoir and past HHD. The results of the monitoring will be presented to the NMFS, USFWS, and WDFW at regularly scheduled five-year reviews. These agencies may recommend changes in

reservoir level management if deleterious impacts to migration from water quality parameters are documented.

Monitor Predator Abundance in the Reservoir. Based on the past experience at other Pacific Northwest reservoir systems, there is concern regarding the potential for predation on downstream-migrating juvenile salmonids. Populations of predators (e.g., northern pikeminnow [*Ptychocheilus oregonensis*]) have been listed as a cause of lower survival of juvenile salmonids in many Northwest systems (Cada et al. 1994; Ledgerwood et al. 1994). Rieman et al. (1991) estimated that 14 percent of all juvenile salmonids that enter the John Day Reservoir on the Columbia River are consumed by a combination of northern pikeminnow, walleye (*Stizostedion vitreum*), and/or smallmouth bass (*Micropterus dolomieui*). While existing surveys of the HHD reservoir area do not suggest the likely presence of warmwater gamefish or large populations of northern pikeminnow, large resident trout or residualized salmon may present a predation risk under future project operations. This monitoring measure will track predator populations and indicate if a predator build-up is occurring as a result of the AWS project. If such a build-up does occur, the population of large predatory fish may be cropped to pre-AWS project levels based on recommendations by NMFS and USFWS. If bull trout are observed during any of the surveys, they will not be targeted for removal.

6.3.2 Research Funding Measure RFM-02 (A-E) Flow Management

RESEARCH FUNDING MEASURE NUMBER: RFM-02(A-E)

MEASURE: Flow Management

RFM-02A: Monitor Effect of Flow Management Strategies on Side Channel Habitats

Tacoma will contribute funds for a three-year pre-construction monitoring study to determine the habitat quality, quantity, and juvenile salmonid use of off-channel habitats in the middle Green River, and how that habitat may be enhanced through water management strategies. An initial survey of physical habitat characteristics of side channels in the middle Green River was conducted in the fall of 1996, and an initial survey of juvenile salmonid use conducted in the spring of 1998. Follow-up surveys to document both the physical conditions and biological use of the middle Green River side channels will be conducted prior to initial operation of the HHD downstream fish passage facility.

Following initial operation of the HHD fish passage facility, four years of post-construction monitoring will be conducted. Two years of post-construction monitoring (conducted in project years 1 and 4) will target physical habitat conditions in side

channels. Two additional years of monitoring (in project years 2 and 5) will target observed biological responses to flow management. One additional year of physical habitat monitoring and one additional year of biological monitoring will be funded in each ten-year interval thereafter for the duration of the ITP. Information collected from side channel surveys will be provided to the GRFMC annually to help guide yearly flow release decisions. The results of these studies will be presented to the GRFMC and representatives of agencies responsible for fisheries management to help them determine whether adaptations of the water management strategy on the Green River are required, and to provide valuable information for habitat restoration programs.

RFM-02B: Monitor Steelhead Spawning and Incubation

Tacoma shall provide funding to the MIT and the WDFW to conduct an annual monitoring program aimed at evaluating steelhead spawning and incubation success during the spring and early summer. Surveys will be conducted every seven to ten days in index reaches of the middle Green River extending from just below the Headworks (River Mile [RM] 61.0) to the confluence with Big Soos Creek near Auburn (RM 33.8). The locations of steelhead redds shall be made available to Tacoma and fisheries resource agencies on a real-time basis.

Information collected through the steelhead monitoring surveys will be used, along with an existing flow model, to evaluate the effects of the released flows on steelhead spawning and egg incubation. These data will be used to identify habitats that are affected by refill, and will provide information to the GRFMC that can be used to refine refill operations to minimize the effects of project operations on steelhead embryonic development. Evaluation of water surface elevations necessary to maintain wetted substrates will be used as the basis to refine flows released during refill periods.

RFM-02C: Monitor Downstream Migration of Juvenile Salmonids

Tacoma shall contribute funds to a pre-AWS project monitoring study (i.e., baseline) to document existing characteristics of downstream-migrating juvenile salmonids. Two years of baseline monitoring will be conducted prior to initial operation of the HHD downstream fish passage facility. Annual post-construction monitoring activities shall be conducted in years 1 through 5 of the AWS project and in 2 of every 10 years thereafter for the duration of the ITP. Monitoring within each year will be adjusted for the planned refill strategy, including study of natural and planned freshet releases. This measure will provide information to the GRFMC that can be used to define an adaptive refill and release schedule for the AWS project that will minimize impacts on downstream-migrating juvenile salmonids.

RFM-02D: Monitor Salmon Spawning and Incubation

Tacoma shall provide funding to the MIT and the WDFW to conduct annual surveys to identify the timing of spawning and distribution of salmon redds within the middle Green River during the fall and winter. Salmon redd surveys will be conducted to identify off-channel (e.g., side channels and sloughs) and lateral mainstem habitats that are used by spawning salmonids and may be affected by an early refill schedule. In the event that the data suggest that AWS project operations appear to be conflicting

with salmon incubation conditions, the GRFMC will recommend management adaptations.

RFM-02E: Monitor Salmon Redds and Emergence

Tacoma shall provide funding to the MIT and the WDFW to install fry emergence traps at selected salmon redds identified during the index reach surveys. Traps will be installed in January and February, and visited daily until emergence is complete. Surveys will be conducted annually in years 1, 2 and 3. Results will be reviewed by fisheries agencies annually to suggest minor modifications to the flow regime, and will be synthesized and reported at the first five-year review to provide data that will allow the GRFMC to develop management adaptations to the flow strategy if necessary.

Objective

RFM-02A - Provide data on side channel connectivity and the quality and quantity of habitat provided by various flow release schedules, and evaluate the biological response to flow management to guide development of a flow management strategy.
RFM-02B - Evaluate the effects of the released flows on steelhead spawning and egg incubation.
RFM-02C - Identify changes in juvenile salmonid downstream migration patterns resulting from implementation of the AWS project.
RFM-02D - Identify off channel habitats used by salmonids that are affected by an early refill schedule.
RFM-02E - Evaluate the impact of early refill on salmon emergence and incubation.

Rationale

Monitor Effect of Flow Management Strategies on Side Channel Habitats. In the fall of 1996, Tacoma conducted physical habitat surveys of side channels occurring between the Headworks (RM 61.0) and RM 35.0. A total of 59 side channel areas comprising approximately 15 river miles was identified during the survey. Monitoring side channel habitats under varying flow conditions will be an important tool in guiding future water management strategies, while attempting to increase production of juvenile salmonids in the middle Green River. The proposed methodology for evaluating physical habitat will consist of measuring the stage at side channel inlet and outlet locations, and collecting data on LWD and habitat within each side channel at various flows. A final study plan will be presented to the Services for approval prior to initiating surveys.

Monitor Steelhead Spawning. The majority of the steelhead spawning in the middle Green River occurs from 15 March through 15 June (USACE 1998). Egg incubation continues into July. The WDFW currently monitors steelhead spawning and incubation on the

Green River for fisheries management purposes. A flow model was developed to predict how the proposed project would operate using 1996 reservoir refill rules applied to the historic flow records from 1964 through 1995. The effects of the proposed project on wild winter steelhead spawning and incubation were modeled to quantify how frequently potential steelhead spawning areas would be dewatered under baseline and proposed conditions. The analysis indicated that for the period of record, 1964 through 1995, the most critical time during baseline encompassed the period when steelhead redds are constructed during 1 June through 15 June.

The MIT and WDFW conducts steelhead-spawning surveys in various sections of the Green River. Research monitoring will be conducted to evaluate the effectiveness of flow releases for providing suitable steelhead spawning and incubation conditions in the mainstem. The research results will be reviewed annually at GRFMC meetings and a summary report presented at the first five-year review.

Monitor Downstream Migration of Juvenile Salmonids. Pre-and post-construction monitoring of juvenile salmonid downstream migrations will provide important information regarding migration characteristics and species response to changes in flow management (e.g., early refill, baseline, freshets). In addition, assuming restoration of anadromous salmonids in the upper Green River watershed, such monitoring will provide an index of the success of downstream passage of juveniles, both at HHD and the Headworks. Parameters such as seasonal and diel timing of migration, migrational response to environmental changes (i.e., flow, turbidity, day length, water temperature) by species and by life stage, and observed responses during HHD refill and release will also be evaluated through this monitoring activity. The research results will be reviewed annually at GRFMC meetings and a summary report presented at the first five-year review.

The proposed methodology utilizes a rotary-screw-trap as the primary method of sampling migrating fish (Thedinga et al. 1994). The trap will be located near RM 34 and will be operated from early February through June. Sampling will be conducted during evening hours five days per week with one 24-hour sample randomly selected each week.

Monitor Salmon Spawning and Incubation. Chinook salmon spawning in the Green River starts in late August to early September, while coho and chum salmon usually begin spawning in November (Grette and Salo 1986). The MIT conducts salmon spawning surveys in various sections of the Green River. Research monitoring will be conducted to evaluate the effectiveness of flow releases for maintaining suitable salmon spawning and

incubation conditions in the mainstem. The research results will be reviewed annually at GRFMC meetings and summary report presented at the first five-year review.

Monitor Salmon Redds and Emergence. Chinook salmon spawning in the Green River starts in late August to early September and the eggs and alevins remain within the gravels throughout the winter, emerging February and March. Coho and chum salmon usually begin spawning in November (Grette and Salo 1986), with emergence occurring in the late winter and spring. Chum salmon frequently spawn in side channels that are connected to the river at high flows. Chum salmon generally migrate downstream within a few weeks of emerging from the gravel, and juvenile fish have been known to become trapped in the side channels that become disconnected in the spring (Coccoli 1996). Surveys of salmon emergence will be conducted to evaluate the effectiveness of flow releases for maintaining suitable incubation conditions and side channel connectivity in the mainstem. The research results will be reviewed at GRFMC meetings and a summary report presented at the first five-year review.

6.3.3 Research Funding Measure RFM-03 (A-B) Mainstem Sediment and Woody Debris

RESEARCH FUNDING MEASURE NUMBER: RFM-03 (A-B)

MEASURE: Mainstem Sediment and Woody Debris

RFM-03A: Monitor Distribution of Woody Debris

The LWD management program provides a means of increasing instream LWD throughout the mainstem middle Green River downstream of the Headworks. However, the program must be monitored to ensure that unanchored wood inputs do not detrimentally impact channel stability, public health and safety, or flood control, and that anchored LWD remains stable and functions as intended. Tacoma will fund LWD surveys of the reach between RM 61 and RM 32 in years 1-5 and year 10. **The amount and distribution of LWD between RM 61.5 and RM 32 will be assessed using a modified version of the TFW Level 1 Survey Protocol and Large Woody Debris Jam Methodology.** Additional monitoring at five-year intervals is recommended, but funding for further monitoring will not be part of Tacoma's obligations under this HCP.

If safety or flood control concerns are found to preclude unanchored placement, or if the Services determine continued inputs of unanchored LWD will not effectively contribute to natural stream processes, LWD may be anchored at specific locations. The stability of anchored placements will be conducted as part of compliance monitoring activities described in Chapter 6.1.

A report summarizing data gathered during periodic LWD loading surveys and anchored LWD stability evaluations will be provided to the Services during the five-

year reviews. It is anticipated that the Services, USACE, and the GRFMC will use the monitoring data to adapt the LWD input strategy as needed.

RFM-03B: Monitor Distribution of Sediments below Tacoma Headworks

The amount and composition of sediment stored in the active channel downstream of the input sites will be evaluated by periodic mapping of active in-channel storage sites and surveying cross-sections. Gravel bars will be mapped on low-level aerial photographs taken when flows are less than 300 cfs at the Auburn gage in years 1, 2, 5, and 10 of the HCP. Permanent cross-sections will be installed downstream of the input site near the inlets of major side channels, or in sites where sediment transport calculations suggest that deposition is likely. The cross-sections will be re-surveyed in years 1, 2, 5, and 10 of the HCP. Additional monitoring at five-year intervals is recommended, but funding for monitoring beyond year 10 will not be part of Tacoma's obligations under this HCP.

The results of gravel nourishment monitoring will be reported to the Services following each survey. It is anticipated that the monitoring data will be used by the NMFS, USFWS, USACE, and the GRFMC to refine the placement strategy if needed.

Objective

RFM-03A - Provide data to the NMFS, USFWS, USACE, and the GRFMC that will facilitate an evaluation of the effectiveness of the mainstem LWD management program at restoring LWD recruitment and function in the middle Green River without compromising public health and safety or the viability of downstream flood control measures.

RFM-03B - Provide data to NMFS, USFWS, USACE, and the GRFMC that will facilitate an evaluation of the effectiveness of gravel nourishment activities in the middle Green River at maintaining spawning habitat and side channel connectivity.

Rationale

Monitor Distribution of Woody Debris. Restoring recruitment of wood to the middle Green River requires passing small woody debris, large logs, and rootwads that are trapped behind HHD downstream to the middle Green River. Placing small woody debris and LWD within the active channel at low flows and allowing it to be naturally redistributed by high flows is the most cost-effective means of getting wood back into the system. It is assumed that wood that is deposited within the channel or floodplain during high flows will benefit fish habitat regardless of its final location or configuration.

However, if LWD jams are too frequent or block the entire channel, they may jeopardize or detrimentally impact flood control measures or public health and safety. Monitoring is necessary to make sure that the proposed input process effectively delivers LWD to the

river system and that increased LWD loadings in the middle Green River do not pose unacceptable risks to other beneficial uses of the river.

A survey of LWD loading and distribution in the middle Green River will be conducted after successful LWD recruitment is documented each year for the first five years of the ITP, and in year ten. **The amount and distribution of LWD between the Tacoma Headworks and RM 32 will be assessed using a modified version of the Tacoma Level 1 survey protocol and Large Woody Debris Jams methodology, except that logs wholly in Zone 3 or 4 need not be counted. LWD surveys will be conducted primarily by boat. The minimum size criteria will be modified to reflect a reasonable size for large rivers such as the Green River. A new minimum size criteria will be developed based on a literature review and interviews with practitioners and research scientists currently conducting LWD studies on large rivers. In addition, the minimum piece count of wood required for a wood accumulation to be considered a jam will be modified as appropriate for larger rivers. Debris jams will be further stratified into three categories (small, moderate and large).** ~~Surveys will be conducted using the general approach described in the TFW Ambient Monitoring Level 1 methodology, or a comparable methodology approved by the Services.~~ Information on the LWD loading and distribution will be summarized and presented to the Services at each five-year review. The location of large new LWD jams will be reported to the GRFMC immediately following each survey. If the GRMC concludes that the frequency and size of LWD jams has increased as a result of LWD placement, and that the risk to other beneficial uses has become unacceptable, unrestricted LWD inputs will be halted, and mainstem LWD management will be limited to anchored placement. Alternatively, if the Services determine, based on data presented at the five-year reviews, that continued inputs of unanchored LWD will not effectively contribute to natural stream processes, all or a portion of the LWD allocated to the mainstem LWD management program may be anchored at specific locations within the middle Green mainstem, or redistributed to other approved uses. If the mainstem LWD management program is curtailed at the direction of the Services or GRFMC, funding for this conservation measure will be transferred to other research monitoring measures.

Monitor Distribution of Sediments below Tacoma Headworks. Construction and operation of HHD has blocked the natural downstream transport of gravel-sized sediments in the Green River since 1962. A recent study conducted for the USACE indicated that HHD prevented the delivery of an estimated 6,500 to 19,600 tons (3,900 to 11,800 cubic yards) of coarse bedload per year from the upper Green River basin to depositional reaches in the middle Green River (USACE 1998). The upper watershed previously contributed

more than 90 percent of the alluvial materials deposited by the middle Green River (Mullineaux 1970). Thus, the decreased sediment inputs are believed to have reduced the amount of available spawning gravels downstream of HHD, and could result in disconnection of side channel habitats as the mainstem incises to form an armor layer. Tacoma has agreed to help fund and monitor gravel nourishment activities for years 1-10 as part of the AWS project.

The results of gravel nourishment monitoring will be reported to the GRFMC prior to subsequent gravel placement following each re-survey. Monitoring data will facilitate adaptation of the placement strategy if gravels are not mobilized as efficiently as anticipated, or if alternate placement locations are deemed to be more beneficial biologically. The decision to change the gravel nourishment strategy will be made by the GRFMC with the approval of the NMFS and USFWS.

Initiating gravel placement activities using the most conservative estimate of pre-HHD bedload transport (i.e., 3,900 yd^3/year), and monitoring active storage and channel capacity downstream of the placement site will ensure that aggradation that could compromise flood control measures is identified in a timely manner. If the NMFS, USFWS, USACE, and the GRFMC conclude that continued gravel placement would compromise downstream flood control measures, gravel nourishment will be reduced or halted, and the funds for gravel nourishment monitoring will be redirected to other research monitoring efforts. Conversely, monitoring may also indicate that increasing the amount of gravel input annually would be beneficial. Tacoma will not be obligated to provide additional funding for increased gravel nourishment as a part of this HCP, but funding could be obtained from alternative sources and implemented under the Green River Flow Management Committee's adaptive management program.

Literature Cited

References cited in this chapter are provided in Chapter 10 of the HCP. Chapters 5, 6, and 8 of the HCP contain the primary commitments of Tacoma in support of its application for an ITP. The Underline and Strikeout versions of HCP Chapters 5, 6, and 8 are included in the FEIS to identify changes in the Draft HCP that were made in response to public comments and additional analyses conducted by the Services. A final HCP, including an updated list of references cited in each chapter, will be issued when the Services have reached a decision regarding issuance of an ITP.

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TABLES

8. Costs and Funding of the Conservation, Monitoring, and Research Measures

8.1 Estimated Costs of the Habitat Conservation Measures

The City of Tacoma's (Tacoma) Green River Habitat Conservation Plan (HCP) brings together the results of over 20 years of research, evaluation, discussions, negotiation and legal proceedings regarding Tacoma's water supply operations and watershed management and protection in the Green River basin. As a result of those efforts a variety of permits, agreements, and memorandas of understanding have been developed to gain approval for the continued use of Tacoma's First Diversion Water Right claim and exercise its Second Diversion Water Right. As a result of such discussions, Tacoma has taken an active part in identifying impacts related to its operations and activities, and developing measures to avoid, minimize, or otherwise mitigate such impacts. Over the years, Tacoma entered into agreements to constrain its water withdrawals to protect fish and wildlife resources and to provide a variety of mitigation measures totaling millions of dollars.

In view of the recent listing of Pacific Northwest species such as the chinook salmon, and the potential for future listings under the Endangered Species Act (ESA), Tacoma re-evaluated its water supply and watershed protection activities. Tacoma prepared this HCP to support its application for an Incidental Take Permit (ITP) in order to gain certainty over its ability to meet the current and future water demands of its customers. In many cases, water supply restrictions and mitigation efforts developed through other proceedings served to satisfy requirements of the ESA. In other cases, new habitat conservation measures were developed to ensure that Tacoma's activities are in compliance with the ESA.

The habitat conservation measures identified in Chapter 5 represent Tacoma's best efforts to avoid, minimize, or otherwise mitigate impacts associated with water supply and watershed protection activities. The total estimated cost of the habitat conservation measures, including measures developed as part of prior agreements and conservation measures developed specifically as part of this HCP, total approximately $57,000,000 (Table 8-1). The majority of the costs of the habitat conservation measures represent commitments made by Tacoma as part of agreements reached for the Second Supply Project, the 1995 Muckleshoot Indian Tribe/Tacoma Public Utilities (MIT/TPU) Settlement Agreement and as local sponsor for the U.S. Army Corps of Engineers' (USACE)

Table 8-1. Estimated Costs of Habitat Conservation Measures identified in Tacoma's Green River Habitat Conservation Plan (cost in 1997 dollars x $1,000 for 50 year term of the Incidental Take Permit)

Measure	Description	Joint (Tacoma/USACE/other) Funding Estimate [1]	Tacoma Only Funding Estimate	Total
HCM 1-01	Minimum Instream Flows	$0	100%	[2]
HCM 1-02	Seasonal Restrictions on SDWR	$0	100%	[2]
HCM 1-03	Tacoma Headworks Upstream Fish Passage Facility	$0	$2,530	$2,530
HCM 1-04	Tacoma Headworks Downstream Fish Bypass Facility	$0	$3,060	$3,060
HCM 1-05	Tacoma Headworks Large Woody Debris (LWD)/Rootwad Placement	$0	10	10
HCM 2-01	HHD Downstream Fish Passage Facility	$34,000	$0	$34,000
HCM 2-02	HHD Non-Dedicated Storage and Flow Management Strategy	$125	$0	$125
HCM 2-03	Upper Watershed Stream, Wetland, and Reservoir Shoreline Rehabilitation Measures	$1,099	$0	$1,099
HCM 2-04	Standing Timber Retention	$0	$1,090[5]	$1,090
HCM 2-05	Juvenile Salmonid Transport and Release [3]	$0	$287	$287
HCM 2-06	Low Flow Augmentation [4]	$0	$400	$400
HCM 2-07	Side Channel Re-connection Signani Slough	$947	$0	$947
HCM 2-08	Woody Debris Management Program	$500	$500[5]	$1,000
HCM 2-09	Mainstem Gravel Nourishment	$4,700	$0	$4,700
HCM 2-10	Headwater Stream Rehabilitation	$341	$0	$341
HCM 2-11	Snowpack and Precipitation Monitoring	$71	$0	$71
HCM 3-01	Upland Forest Management Measures	$0	$2,129[5]	$2,129
HCM 3-02	Riparian Management Measures	$0	$3,000[5]	$3,000
HCM 3-03	Road Construction and Maintenance Measures	$0	$1,714	$1,714
HCM 3-04	Species-specific Management Measures	$0	$741	$741
TOTAL ESTIMATED COST		**$41,783**	**$15,461**	**$57,244**

[1] The Joint Funding estimate represents a cost-share arrangement between Tacoma, the USACE, and other potential partners. The cost-share percentages are subject to change in the Water Resource Development Act, other Congressional initiatives, or USACE Section 7 requirements under the Endangered Species Act. **Tacoma's share of the Joint Funding commitment has not been determined, but is expected to range between 20 and 50 percent. The Tacoma Only funding estimate refers to those measures that will be funded solely by Tacoma and are in addition to Tacoma's share of the Joint Funding commitment.**

[2] Costs associated with this measure are opportunity costs that will only occur in extreme drought years. Prior guarantee of funding is not necessary to ensure compliance with the conditions of the HCP.

[3] Estimated capital expenditure, no operational costs included.

[4] Tacoma expenditure, USACE costs not included.

[5] ~~Lost revenue included in funding estimates~~ **The value of lost revenue is included in funding estimates. The cost associated with HCM 2-04 is the foregone value associated with leaving merchantable timber standing in the new inundation zone (elevation 1,141 ft to 1,167 ft) of Howard Hanson Reservoir. The cost of HCM 2-08 includes the foregone value resulting from using the wood debris collected in the reservoir for habitat restoration purposes rather than selling it. The costs of HCM 3-01 include opportunity costs associated with leaving merchantable timber standing in reserves; opportunity costs of extending rotations outside reserves; and management costs associated with delineating, working around, and monitoring special management areas. The estimated costs for HCM 3-02 are primarily the foregone value resulting from leaving merchantable timber in riparian buffers and include the value associated with foregoing timber harvest to comply with both the Washington Forest Practice Rules and HCM 3-02. The HCP requirements are considerably greater than current state Forest Practices Rules, and they will result in the retention of a least double the timber volume.**

Additional Water Storage project at Howard Hanson Dam (HHD). Much of these costs represent cost-share arrangements between Tacoma and the USACE or other entities.~~; however, approximately 27 percent of these costs are funded by Tacoma.~~

The costs of this HCP represent Tacoma's commitment to manage its water supply in a manner that addresses the needs of the people of South Puget Sound along with the needs of the fish and wildlife in the Green River basin. In some cases, such as restrictions on the use of the First Diversion Water Right claim (HCM 1-01) and additional constraints on the exercise of the Second Diversion Water Right (HCM 1-02), the value to Tacoma of the lost opportunity for additional water supply was not included as a cost under the HCP (see Table 8-1). These costs would only be realized as reduced revenues in extreme drought years, and not as capital expenditures that would require a guarantee in order to ensure successful implementation of the HCP.

As co-sponsors of the Additional Water Storage (AWS) project at HHD, Tacoma and the USACE have agreed to cost-share many funding requirements outlined in this Habitat Conservation Plan. The final cost-share agreement will be subject to negotiations. The USACE must first define its obligations in consultation with the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) under Section 7 of the ESA. ~~The USACE will then need to secure the necessary appropriations from Congress to meet its obligations.~~ Tacoma will define its financial obligations in this HCP as provided for under Section 10 of the ESA. A final resolution of the exact cost-share arrangement will depend on the outcome of the USACE negotiations. ~~The AWS project, and associated incidental take of listed species, will not occur until funding obligations are finalized.~~

8.2 Estimated Costs of the Monitoring and Research Program

As described in Chapter 6, Tacoma will implement a monitoring and research program consisting of three main types of measures: compliance monitoring to ensure conservation measures are implemented according to specified standards; effectiveness monitoring to provide feedback to improve the performance and functionality of measures where Tacoma is responsible for ensuring results; and funding of a research program designed to provide resource agencies and the MIT with information needed to adaptively manage the natural resources of the Green River on a real-time basis.

8.2.1 Compliance Monitoring

Funds required to implement compliance monitoring will be provided by Tacoma alone or in conjunction with other agencies. In most cases, compliance monitoring consists of verification that the conservation measures have been funded or implemented. Project completion reports or annual summaries of activities conducted specific to each measure will be prepared and submitted as described in Chapter 5. Tacoma has estimated that costs to conduct compliance monitoring over the 50-year term of the Incidental Take Permit will not exceed $**600,000**~~500,000~~. This amount represents potential cost-share arrangements between Tacoma and the USACE or other agencies. The cost-share percentages are subject to change. Cost-reductions identified through increased efficiencies, competitive bids, or coordinated efforts with ongoing project operations will accrue to Tacoma or other funding agencies.

8.2.2 Effectiveness Monitoring

Funds required to implement effectiveness monitoring will be provided by Tacoma. Changes to habitat conservation measures HCM 3-01G (Snags, Green Recruitment Trees and Logs) and HCM 3-04 (Species-specific Management Measures) as a result of monitoring efforts may reduce Tacoma's income from timber harvest in the upper watershed. It is difficult to predict the extent of such adaptations to the conservation measures; however, any change will be primarily reflected in changes in Tacoma's revenue from timber harvest in the upper watershed. Revenue from timber sales on Tacoma lands in the Green River watershed is used for additional land acquisition and forest management and water quality enhancement projects in the upper watershed. Reductions in revenue will reduce the rate of land acquisition, but will not represent additional cash outlays on the part of Tacoma or interfere with effective implementation of the HCP.

8.2.3 Research Monitoring

Funds required for the research monitoring program will be provided by Tacoma, alone or in conjunction with other agencies. Annual funding of the research efforts will begin immediately following construction of the Additional Water Storage project at HHD. The intent of the research fund is to allow the USACE to coordinate with the Green River Flow Management Committee to assist in the design of an annual Green River research program, subject to approval of the NMFS and the USFWS. Details of the research program are identified in Chapter 6 of this HCP. The program addresses three primary areas of uncertainty associated with rehabilitation of natural resources of the Green River:

1) downstream fish passage at HHD (including reservoir and dam passage);
2) flow management in the middle and lower Green River; and
3) sediment and woody debris transport.

Contributions to the research fund during the first ten years of the AWS project represents a cost-share arrangement between Tacoma and the USACE or other agencies. The cost-share percentages are subject to changes in the Water Resource Development Act, other Congressional funding initiatives, or USACE requirements under Section 7 of the ESA. During the first ten years of the research program, Tacoma will share the funding commitment associated with downstream fish passage, flow management and sediment and woody debris transport measures. Total expenditures under the research program cannot exceed the sum of all individual measures.

A total of $3,432,000 has been allocated to the research fund during the first ten years of the research program (Table 8-2). This sum does not include $100,000 paid directly to the MIT and the Washington State Department of Fish and Wildlife to conduct annual steelhead spawning surveys as per the 1995 MIT/TPU Agreement. The $3,432,000 joint USACE/Tacoma cost-share, and the $100,000 to be paid directly by Tacoma to the MIT and WDFW combine to total the $3,532,000 allocated to fund research and adaptive management within the first ten years of the program (Table 8-2).

The funding stream represents a firm commitment that will not be reduced due to increased efficiencies, coordination of research efforts or contributions by other agencies. However, Tacoma recognizes that changes in the allocation of funds among different elements of the research fund may be desirable during implementation. To retain the integrity of the HCP but also allow flexibility, funds can be transferred between measures subject to approval of the USACE, the NMFS, and the USFWS. Such changes will be made subject to the cost cap of $3,432,000 during the first ten years of the research program.

During years 11 through 50 of the research program, Tacoma will provide complete funding for flow management measures identified in Table 8-2. During this period, funds can be transferred between flow management measures within specific years, or funds for a current year can be retained and carried forward to supplement future expenditures. Funds allocated for future flow management research efforts cannot be advanced to

Table 8-2. Estimated costs for research and adaptive management associated with Tacoma's Green River Habitat Conservation Plan.

Research Measure	Research Issue	Description of Research Activity	Cost (in thousands of dollars)															Total Cost Yrs 1-50
			1	2	3	4	5	6-10[1]	Subtotal Yrs 1-10	11-15[1]	16-20[1]	21-25[1]	26-30[1]	31-35[1]	36-40[1]	41-45[1]	46-50[1]	
Downstream Fish Passage	Reservoir Passage of Juvenile Fish	Fyke nets	35	35	35	35	35	70	245									**245**
Downstream Fish Passage	Reservoir Passage of Juvenile Fish	Hydroacoustics (mobile)		50	50		50	50	200									**200**
Downstream Fish Passage	Reservoir Passage of Juvenile Fish	Paired PIT-tag releases	120	120			120	120	48				Funding for the monitoring of					**480**
Downstream Fish Passage	Reservoir Passage of Juvenile Fish	Screw trap at HHD outlet			94	94	94	94	376				downstream fish passage in					**376**
Downstream Fish Passage	Fish Collector Passage	Sampling station	30	30	30	30	30	150	300				years 11 through 50 will not be part					**300**
Downstream Fish Passage	Fish Passage Facility	Marked fry	20	20	20				60				of Tacoma's obligations under					**60**
Downstream Fish Passage	Fish Passage Facility	Hydroacoustics (forebay/wetwell)	70	70	70	70	70	70	420				Section 10 of the ESA.					**420**
Downstream Fish Passage	Reservoir Passage of Juvenile Fish	Zooplankton abundance/water quality	30				30	30	90									**90**
Downstream Fish Passage	Reservoir Passage of Juvenile Fish	Predator abundance			45		45	25	115									**115**
SUBTOTAL			**305**	**325**	**344**	**229**	**474**	**609**	**2,286**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2,286**
Flow Management	Side-channel Connectivity	Side-channel (physical)	35			35		35	105	35	35	35	35	35	35	35	35	**385**
Flow Management	Side-channel Connectivity	Side-channel (biological)		38			38	38	114	38	38	38	38	38	38	38	38	**418**
Flow Management	Steelhead Spawning[2]	Redd surveys	10	10	10	10	10	50	100	50	50	50	50	50	50	50	50	**500**
Flow Management	Juvenile Instream Migration	Screw trap (RM 34)[3]	94	94	94	94	94	94	564		188		188		188		188	**1,316**
Flow Management	Spawning Surveys Above and Below HHD	Salmon spawning surveys	15	15	15	15	15	50	125	50	50	50	50	50	50	50	50	**525**
Flow Management	Incubation	Redd monitor/emergence traps	30	30	30				90									**90**
SUBTOTAL[2]			**184**	**187**	**149**	**154**	**157**	**267**	**1,098**	**173**	**361**	**173**	**361**	**173**	**361**	**173**	**361**	**3,234**
Sediment/Wood Transport	Mainstem Woody Debris Survey	Survey mainstem river (RM 61.5-RM33)	8	8	8	8	8	8	48	Funding for the monitoring of sediment/wood transport in years 11 through 50 will not be part of Tacoma's obligation under Section 10 of the ESA.								**48**
Sediment/Wood Transport	Gravel Nourishment	Monitor gravel placement	25	25			25	25	100									**100**
SUBTOTAL			**33**	**33**	**8**	**8**	**33**	**33**	**148**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**148**
TOTAL HCP / AWSP[2]			**522**	**545**	**501**	**391**	**664**	**909**	**3,532**	**173**	**361**	**173**	**361**	**173**	**361**	**173**	**361**	**5,668**

1 Cost represents cumulative total for monitoring conducted over the five-year period.
For example, steelhead redd surveys, at $10,000 per year will be conducted annually for a cumulative total of $50,000 every five years.

2 Cost to support steelhead spawning surveys will be paid directly to the MIT and the Washington State Department of Fish and Wildlife and will not be co-mingled with the Research Fund.

3 Screw traps will be deployed an average of two consecutive years every ten years during years 6-50.

supplement ongoing research efforts. Such changes will be made subject to the flow management research program cost cap of $1,736,000. This amount does not include funds paid directly to the MIT and the Washington State Department of Fish and Wildlife to conduct annual steelhead spawning surveys as per the 1995 MIT/TPU Agreement. Tacoma will not provide funding support for downstream fish passage and sediment and woody debris transport measures during years 11 through 50 of the research program. Funding support for these measures during years 11 through 50 of the research program must be provided by other entities.

8.3 TOTAL ESTIMATED COSTS OF THE HABITAT CONSERVATION PLAN

Total costs for the Green River HCP are approximately $**63,512,000** ~~63,412,000~~ (Table 8-3). Approximately $17,697,000 of those costs, or about 28 percent, represents a funding commitment of Tacoma. The other 72 percent of those costs represent cost-share arrangements between Tacoma and other entities. Tacoma will fund its commitments made in the HCP, subject to the overall research cost cap established for the HCP. Funding will be from sources at Tacoma's discretion, including, but not limited to revenues from the sale of water, timber and land, and from outside sources such as grants or contributions. All cost estimates and commitments in the HCP are given in 1997 dollars.

Table 8-3. Summary of Tacoma's Funding of the Green River HCP (cost in 1997 dollars x 1,000 for 50-year term of the Incidental Take Permit).

Activity	Joint USACE/ Tacoma Funding	Tacoma Funding	Total
HCM Cost Estimate	$41,783	$15,461	$57,244
Compliance Monitoring Cost Estimate [1]	$600	$0	$600
Effectiveness Monitoring Cost Estimate	$0	[2]	[2]
Research Funding Commitment [3]			
Downstream Fish Passage	$2,286	$0	$2,286
Flow Management	$998	$1,736	$2,734
Sediment / Wood Transport	$148	$0	$148
MIT/WDFW Research Funding	$0	$500	$500
Total	$45,815	$17,697	$63,512

[1] Tacoma's contribution to compliance monitoring includes potential cost-share arrangements between Tacoma and the U.S. Army Corps of Engineers or other agencies. The cost-share percentages are subject to change. Cost-reductions identified through increased efficiencies, competitive bids or coordinated efforts with ongoing project operations will accrue to Tacoma or other funding agencies.

[2] Costs associated with these measures are opportunity costs that will occur only if it is necessary for Tacoma water to increase green-tree retention and reduce overall timber harvest revenues in the upper Green River watersheds. Such reductions in timber revenues will not interfere with the implementation of the HCP.

[3] Tacoma's contribution to research funding during years 1-10 of the Additional Water Storage Project represents a cost-share arrangement between Tacoma and the USACE or other agencies. The cost-share percentages are subject to changes in the Water Resource Development Act, other Congressional initiatives, or USACE requirements under Section 7 of the Endangered Species Act. The funding stream represents a firm commitment that will not be reduced due to increased efficiencies, coordination of research efforts or contributions by other agencies.

HCM Habitat Conservation Measure
MIT Muckleshoot Indian Tribe
WDFW Washington State Department of Fish and Wildlife
USACE U.S. Army Corps of Engineers